# Rules and Regulations for the Classification of Linkspans

July 2020

Lloyd's Register

# A guide to the Rules

*and published requirements*

## Rules and Regulations for the Classification of Linkspans

## Introduction

The Rules are published as a complete set; individual Parts are, however, available on request. A comprehensive List of Contents is placed at the beginning of each Part.

## Rules updating

The Rules are generally published annually and changed through a system of Notices between releases.

July 2020

## ■ *Section 1* Background

1.1 Lloyd’s Register Group Limited is a registered company under English law, with origins dating from 1760. It was established for the purpose of producing a faithful and accurate classification of merchant shipping. It now primarily produces classification Rules.

1.2 Classification services are delivered to clients by a number of other members subsidiaries and affiliates of Lloyd’s Register Group Limited, including but not limited to: Lloyd’s Register EMEA, Lloyd’s Register Asia, Lloyd’s Register North America, Inc., and Lloyd’s Register Central and South America Limited. Lloyd’s Register Group Limited, its subsidiaries and affiliates are hereinafter, individually and collectively, referred to as ‘LR’.

## ■ *Section 2* Governance

2.1 Lloyd’s Register Group Limited is managed by a Board of Directors (hereinafter referred to as 'the Board').

The Board has:

appointed a Classification Committee and determined its powers and functions and authorised it to delegate certain of its powers to a Classification Executive and Devolved Classification Executives;

appointed Technical Committees and determined their powers, functions and duties.

2.2 LR has established National and Area Committees in the following:

| Countries: | Areas: |
|---|---|
| Australia (via Lloyd's Register Asia) | Benelux (via Lloyd's Register EMEA) |
| Canada (via Lloyd's Register North America, Inc.) | Central America (via Lloyd's Register Central and South America Ltd) |
| China (via Lloyd's Register Asia) | Nordic Countries (via Lloyd's Register EMEA) |
| Egypt (via Lloyd's Register EMEA) | South Asia (via Lloyd's Register Asia) |
| Federal Republic of Germany (via Lloyd's Register EMEA) | Asian Shipowners (via Lloyd's Register Asia) |
| France (via Lloyd's Register EMEA) | Greece (via Lloyd's Register EMEA) |
| Italy (via Lloyd's Register EMEA) | |

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|---|
| Japan (via Lloyd's Register Group Limited) |
| New Zealand (via Lloyd's Register Asia) |
| Poland (via Lloyd's Register (Polska) Sp zoo) |
| Spain (via Lloyd's Register EMEA) |
| United States of America (via Lloyd's Register North America, Inc.) |

## ■ *Section 3* **Technical Committee**

3.1 LR maintains a Technical Committee, at present comprised of a maximum of 80 members, and additionally an Offshore Technical Committee with specific responsibility for LR's Rules for Offshore Units, at present comprised of a maximum of 80 members. Membership of the Technical Committees includes:

*Ex officio members*:

- Chairman and Chief Executive Officer of Lloyd's Register Group Limited
- Chairman of the Classification Committee of Lloyd's Register Group Limited

*Members Nominated by*:

- Technical Committee or Offshore Technical Committee
- Professional bodies representing technical disciplines relevant to the industry
- National and International trade associations with competence relevant to technical issues related to LR's business

3.2 In addition to the foregoing:

(a) Each National or Area Committee may appoint a representative to attend meetings of the Technical Committees.
(b) A maximum of five further representatives from National Administrations may be co-opted to serve on the Technical Committees. Representatives from National Administrations may also be elected as members of the Technical Committees as Nominated Members.
(c) Further persons may be co-opted to serve on the Technical Committees by the relevant Technical Committee.

3.3 All elections are subject to confirmation by the Board.

3.4 The function of the Technical Committees is to consider:

(a) any technical issues connected with LR's business;
(b) any proposed alterations in the existing Rules;
(c) any new Rules for classification;

Where changes to the Rules are necessitated by mandatory implementation of International Conventions and Codes, or Common Rules, Unified Requirements and Interpretations adopted by the International Association of Classification Societies, these may be implemented by LR without consideration by the relevant Technical Committee, although any such changes may be provided to the Technical Committees for information.

Where changes to the Rules are required by LR to enable existing technical requirements within the Rules to be recognised as Class Notations or Descriptive Notes, these may be implemented by LR without consideration by the relevant Technical Committee, although any such changes will be provided to the relevant Technical Committee for information

3.5 The term of office of the Chairman and of all members of each Technical Committee is five years. Members may be re-elected to serve an additional term of office with the approval of the Board. The term of office of the Chairman may be extended with the approval of the Board.

3.6 In the case of continuous non-attendance of a member, the relevant Technical Committee may withdraw membership.

3.7 Meetings of the Technical Committees are convened as often and at such times and places as is necessary, but there is to be at least one meeting in each year. Matters may also be considered by the Technical Committees by correspondence.

3.8 Any proposal involving any alteration in, or addition to the General Regulations, of Rules for Classification is subject to approval of the Board. All other proposals for additions to or alterations to the Rules for Classification other than the General Regulations, will following consideration and approval by the relevant Technical Committee either at a meeting of that Technical Committee or by correspondence, be recommended to the Board for adoption.

3.9 The Technical Committees are empowered to:

(a) appoint sub-Committees or panels; and
(b) co-opt to the Technical Committee, or to its sub-Committees or panels, representatives of any organisation or industry or private individuals for the purpose of considering any particular problem.

## ■ *Section 4* **Naval Ship Technical Committee**

4.1 LR's Naval Ship Technical Committee is at present composed of a maximum of 50 members and includes:

*Ex officio members:*

- Chairman and Chief Executive Officer of Lloyd's Register Group Limited

*Member nominated by:*

- Naval Ship Technical Committee;
- The Royal Navy and the UK Ministry of Defence;
- UK Shipbuilders, Ship Repairers and Defence Industry;
- Overseas Navies, Governments and Governmental Agencies;
- Overseas Shipbuilders, Ship Repairers and Defence Industries;

4.2 All elections are subject to confirmation by the Board.

4.3 All members of the Naval Ship Technical Committee are to hold security clearance from their National Authority for the equivalent of NATO CONFIDENTIAL. All material is to be handled in accordance with NATO Regulations or, for non-NATO countries, an approved equivalent. No classified material shall be disclosed to any third party without the consent of the originator.

4.4 The term of office of the Naval Ship Technical Committee Chairman and of all members of the Naval Ship Technical Committee is five years. Members may be re-elected to serve an additional term of office with the approval of the Board. The term of the Chairman may be extended with the approval of the Board.

4.5 In the case of continuous non-attendance of a member, the Naval Ship Technical Committee may withdraw membership.

4.6 The function of the Naval Ship Technical Committee is to consider technical issues connected with Naval Ship matters and to approve proposals for new Naval Ship Rules, or amendments to existing Naval Ship Rules. Where appropriate, Naval Ship Technical Committee may also recognise alternative LR Rule requirements that have been approved by the other Lloyd's Register Technical Committee as adjunct to the Naval Ship Rules.

4.7 Meetings of the Naval Ship Technical Committee are convened as necessary but there will be at least one meeting per year. Urgent matters may be considered by the Naval Ship Technical Committee by correspondence.

4.8 Any proposal involving any alteration in, or addition to, the General Regulations of Rules for Classification of Naval Ships is subject to approval of the Board. All other proposals for additions to or alterations to the Rules for Classification of Naval Ships, other than the General Regulations, will following consideration and approval by the Naval Ship Technical Committee, either at a meeting of the Naval Ship Technical Committee or by correspondence, be recommended to the Board for adoption.

4.9 The Naval Ship Technical Committee is empowered to:

(a) appoint sub-Committees or panels; and
(b) co-opt to the Naval Ship Technical Committee, or to its sub-Committees or panels, representatives of any organisation or industry or private individuals for the purpose of considering any particular problem.

## Section 5
## Applicability of Classification Rules and Disclosure of Information

5.1 LR has the power to adopt, and publish as deemed necessary, Rules relating to classification and has (in relation thereto) provided the following:

(a) Except in the case of a special directive by the Board, no new Regulation or alteration to any existing Regulation relating to classification or to class notations is to be applied to existing ships.

(b) Except in the case of a special directive by the Board, or where changes necessitated by mandatory implementation of International Conventions, Codes or Unified Requirements adopted by the International Association of Classification Societies are concerned, no new Rule or alteration in any existing Rule is to be applied compulsorily after the date on which the contract between the ship builder and shipowner for construction of the ship has been signed, nor within six months of its adoption. The date of 'contract for construction' of a ship is the date on which the contract to build the ship is signed between the prospective shipowner and the ship builder. This date and the construction number (i.e. hull numbers) of all the vessels included in the contract are to be declared by the party applying for the assignment of class to a newbuilding. The date of 'contract for construction' of a series of sister ships, including specified optional ships for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective shipowner and the ship builder. In this section a 'series of sister ships' is a series of ships built to the same approved plans for classification purposes, under a single contract for construction. The optional ships will be considered part of the same series of sister ships if the option is exercised not later than 1 year after the contract to build the series was signed. If a contract for construction is later amended to include additional ships or additional options, the date of 'contract for construction' for such ships is the date on which the amendment to the contract is signed between the prospective shipowner and the ship builder. The amendment to the contract is to be considered as a 'new contract'. If a contract for construction is amended to change the ship type, the date of 'contract for construction' of this modified vessel, or vessels, is the date on which the revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder. Where it is desired to use existing approved ship or machinery plans for a new contract, written application is to be made to LR. Sister ships may have minor design alterations provided that such alterations do not affect matters related to classification, or if the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the ship builder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to LR for approval. Recognising the long time period that may occur between the initial design contract and the contract for construction for offshore units for fixed locations, the date determining effective classification requirements will be specially considered by LR in such cases.

(c) All reports of survey are to be made by surveyors authorised by members of the LR Group to survey and report (hereinafter referred to as 'the Surveyors') according to the form prescribed, and submitted for the consideration of the Classification Committee.

(d) Information contained in the reports of classification and statutory surveys will be made available to the relevant owner, National Administration, Port State Administration, P&I Club, hull underwriter and, if authorised in writing by that owner, to any other person or organisation.

(e) Notwithstanding the general duty of confidentiality owed by LR to its client in accordance with the LR Rules, LR clients hereby accept that, LR will participate in the IACS Early Warning System which requires each IACS member to provide its fellow IACS members and Associates with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and utilised to facilitate the proper working of the IACS Early Warning System. LR will provide its client with written details of such information upon sending the same to IACS Members and Associates.

(f) Information relating to the status of classification and statutory surveys and suspensions/withdrawals of class together with any associated conditions of class will be made available as required by applicable legislation or court order.

(g) A Classification Executive consisting of senior members of LR's Classification Department staff shall carry out whatever duties that may be within the function of the Classification Committee that the Classification Committee assigns to it.

## Section 6
## Ethics

6.1 No LR Group employee is permitted under any circumstances, to accept, directly or indirectly, from any person, firm or company, with whom the work of the employee brings the employee into contact, any present, bonus, entertainment or honorarium of any sort whatsoever which is of more than nominal value or which might be construed to exceed customary courtesy extended in accordance with accepted ethical business standards.

## Section 7
## Non-Payment of Fees

7.1 LR has the power to withhold or, if already granted, to suspend or withdraw any ship from class (or to withhold any certificate or report in any other case), in the event of non-payment of any fee to any member of the LR Group.

## Section 8
## Limits of Liability

8.1 When providing services LR does not assess compliance with any standard other than the applicable LR Rules, international conventions and other standards agreed in writing.

8.2 In providing services, information or advice, LR does not warrant the accuracy of any information or advice supplied. Except as set out herein, LR will not be liable for any loss, damage or expense sustained by any person and caused by any act, omission, error, negligence or strict liability of LR or caused by any inaccuracy in any information or advice given in any way by or on behalf of LR even if held to amount to a breach of warranty. Nevertheless, if the Client uses LR services or relies on any information or advice given by or on behalf of LR and as a result suffers loss, damage or expense that is proved to have been caused by any negligent act, omission or error of LR or any negligent inaccuracy in information or advice given by or on behalf of LR then LR will pay compensation to the client for its proved loss up to but not exceeding the amount of the fee (if any) charged for that particular service, information or advice.

8.3 LR will print on all certificates and reports the following notice: Lloyd's Register Group Limited, its affiliates and subsidiaries and their respective officers, employees or agents are, individually and collectively, referred to in this clause as ‘Lloyd's Register’. Lloyd's Register assumes no responsibility and shall not be liable to any person for any loss, damage or expense caused by reliance on the information or advice in this document or howsoever provided, unless that person has signed a contract with the relevant Lloyd's Register entity for the provision of this information or advice and in that case any responsibility or liability is exclusively on the terms and conditions set out in that contract.

8.4 Except in the circumstances of section *Pt 1, Ch 1, 8 Limits of Liability 8.2* above, LR will not be liable for any loss of profit, loss of contract, loss of use or any indirect or consequential loss, damage or expense sustained by any person caused by any act, omission or error or caused by any inaccuracy in any information or advice given in any way by or on behalf of LR even if held to amount to a breach of warranty.

8.5 Any dispute about LR services is subject to the exclusive jurisdiction of the English courts and will be governed by English law.

## ■ *Section 1* Conditions for classification

### 1.1 General

1.1.1 The *Rules and Regulations for the Classification of Linkspans*, hereinafter referred to as the Rules, are applicable to those types of facilities which are defined in *Pt 1, Ch 2, 1.2 Application 1.2.1*.

1.1.2 Assignment of classification will, on compliance with these Rules, be granted by the Committee on the basis that the designers, builders, repairers, Owners and operators of the linkspan:

(a) bear the prime responsibility for all the safety-related aspects of the linkspan which fall within the scope of their intervention;
(b) have fully acquainted themselves with the scope of these Rules and the associated obligations laid down herein;
(c) have satisfied themselves that these Rules are sufficient for their purposes;
(d) are aware of their obligations under all National and International codes and statutory requirements which may be applicable.

1.1.3 The Rules are based on the understanding that:

(a) the linkspan will, at all times, be properly loaded in accordance with the designer's instructions and the loading conditions approved by LR;
(b) the linkspan will, at all times, be properly operated by trained and authorized personnel;
(c) the linkspan will be maintained by qualified and authorized personnel;
(d) compliance with the Rules does not relieve the designers and/or builders/contractors of their contractual responsibilities to their Client for compliance with the specification and the requirements for the overall design and in-service performance of the linkspan;
(e) the linkspan will not be operated outside the parameters specified in the approval and in the class notation without the prior agreement of LR.

1.1.4 New linkspans which are designed, constructed and installed in accordance with the Rules, will be assigned a class and will continue to be classed so long as they are found, upon examination at the prescribed surveys, to be maintained in accordance with the requirements of the Rules to the satisfaction of the Committee. Classification will be conditional upon compliance with all requirements of LR.

1.1.5 The class notations of these linkspans will be recorded in the *Maritime Guide*. *See also Pt 1, Ch 2, 3 Class characters and notations*.

1.1.6 LR will require to be satisfied that linkspans are suitable for the environmental conditions at the intended geographical service locations and which may not apply if the linkspan is moved to a different location.

1.1.7 Any damage, defect, breakdown or grounding, which could adversely affect the ability of the linkspan to accommodate the conditions for which a class has been assigned, is to be reported to LR by its client without delay.

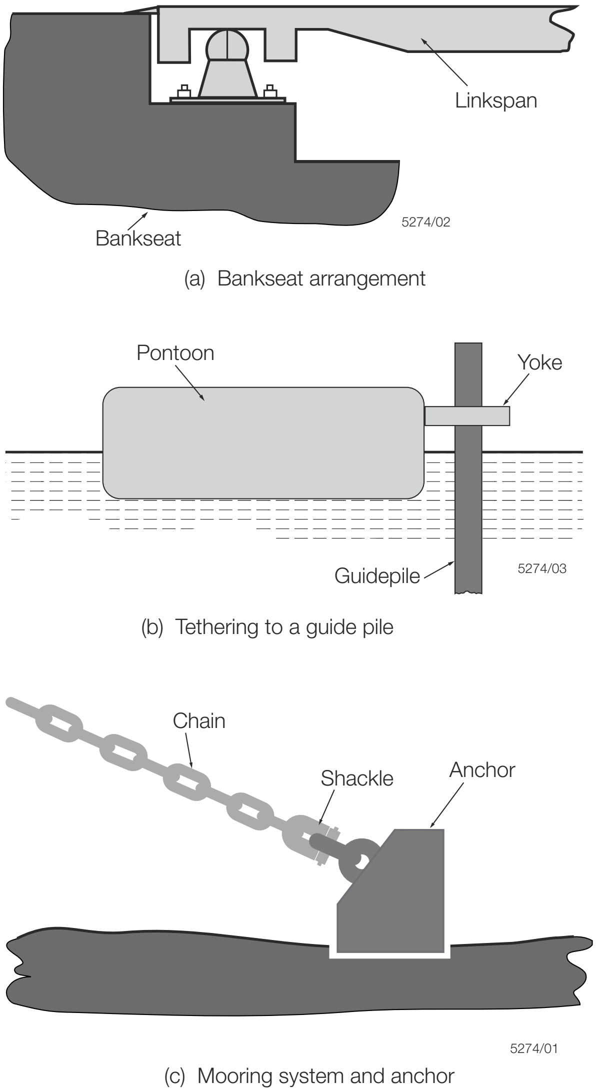



**Figure 2.1.1 Interface works**

### 1.2 Application

1.2.1 These Rules apply to the classification of linkspans which, unless formally agreed otherwise by LR, are defined as follows:

Linkspans are non-self-propelled marine facilities, sited at fixed locations normally within protected waters (*see Pt 1, Ch 2, 1.2 Application 1.2.5*), for the transfer of vehicular and/or passenger traffic between shore and ship.

For the purposes of this definition a linkspan may be:

- a floating structure or may derive its support from non-buoyant means, or a combination of both;
- linked to the shore by a single or multiple system of bridges, ramps or walkways;
- held on station by a mooring system or a tethering arrangement consisting of a system of guidepiles or dolphins, or other tethering arrangements, *see Pt 1, Ch 2, 1.3 Scope of classification 1.3.4*.

1.2.2 Classification in accordance with these Rules is normally assigned on the basis that the linkspan will not fulfil any station-keeping function for the ships which use it. Should any such station-keeping function be contemplated, full details are to be submitted at the earliest possible stage so that the feasibility of the proposal can be considered. The classification of any such linkspan will be specially considered.

1.2.3 If it is intended, despite the definition given in *Pt 1, Ch 2, 1.2 Application 1.2.1*, to operate a linkspan at a location outside protected waters, full details are to be submitted at the earliest possible stage in order to establish the feasibility of the proposal. The classification of any such linkspan will be specially considered.

1.2.4 These Rules do not apply to the classification of ship-mounted ramps. For ship-mounted ramps *see Pt 3, Ch 9, 3 Drag coefficients for pontoons* of the *Rules and Regulations for the Classification of Ships* (hereinafter referred to as the Rules for Ships) and *Ch 5, 3 Materials of construction* of the LR *Code for Lifting Appliances in a Marine Environment* (LAME Code).

1.2.5 For the purposes of these Rules, protected water is defined as an area which, if connected to open water, is substantially shielded from the sea states associated with the open water by the configurations of the land and/or infrastructure which partially surround the area. In any particular situation, the degree of protection required depends on the severity of the open water sea states to be attenuated and on the structural sensitivity of the items within the area to be protected. This is a question of judgement which, when doubt exists, will normally require resolution by the measures indicated in *Pt 3, Ch 1, 2.1 General 2.1.1*. Open water is an area having a fetch in excess of six nautical miles.

1.2.6 These Rules may not apply to ramps, bridges and walkways which are intended to be mechanically hoisted and lowered when loaded with vehicles or passengers. If it is intended that they may be mechanically hoisted or lowered when loaded with passengers or vehicles then that element will be treated as a lifting appliance and the requirements of the appropriate sections of LR's *Code for Lifting Appliances in a Marine Environment, July 2020* will also apply. Additionally, other National Standards may be applicable.

1.2.7 For the purposes of these Rules the term machinery is to cover all aspects of engineering systems described in *Pt 4 Engineering Systems*.

1.2.8 For the purposes of these Rules the term ship is to be taken to cover any type of marine craft suitable for the installation.

1.2.9 For the purposes of these Rules the term walkway is to be taken to cover any type of walkway which is part of the linkspan and is designed to be used by passengers and others for boarding a ship. It does not include walkways/platforms/ ladders, etc. solely provided for service/maintenance/inspection purposes of the linkspan or any walkways which are not part of the linkspan such as ships' gangways, accommodation ladders, brows and pilot ladders.

1.2.10 For the purposes of these Rules the term operators is taken to mean the authority or authorities appointed to manage the operation and maintenance of the linkspan. The operators may be the Owners of the linkspan.

1.2.11 For the purposes of these Rules the term passenger in relation to a walkway is to include all persons, and where appropriate animals, who may use that walkway.

### 1.3 Scope of classification

1.3.1 Classification covers the design, construction and Periodical Survey of the linkspan to the extent indicated within the Rules. However, coverage may, in special circumstances, and by formal agreement with LR, be extended to cover the further aspects indicated in *Pt 1, Ch 2, 1.2 Application 1.2.2 Pt 1, Ch 2, 1.2 Application 1.2.3*, *Pt 1, Ch 2, 1.2 Application 1.2.4*, *Pt 1, Ch 2, 1.2 Application 1.2.5* and *Pt 1, Ch 2, 1.2 Application 1.2.6*.

1.3.2 For each such aspect the extent of LR classification coverage is strictly limited to the requirements indicated in these Rules, and it is achieved by way of the intervention of LR Surveyors at the appropriate stages of design, construction, installation, commissioning, and, periodically, during service.

1.3.3 The in-service stability of the linkspan is the responsibility of the operators.

1.3.4 Interface works, such as the bankseats, guidepiles or dolphins and anchors, and the associated sea-bed conditions, where applicable, and approach roads and bridges are not within the scope of classification. Components of the mooring/ tethering arrangement such as chains, mooring ropes and mooring arm structures are to comply with the requirements of *Pt 3, Ch 7 Mooring and Tethering Arrangements Figure 2.1.1 Interface works* indicates items included in classification (lighter shading) and those outwith classification (darker shading).

1.3.5 Where a linkspan is so badly damaged that class has to be suspended, LR is prepared to assist the operators with advice on measures to be taken for reclassification, if requested.

1.3.6 The attention of Owners/operators, builders and designers is drawn to statutory requirements which may be imposed by the relevant National Administration and which may not be within the scope of classification. If there is any conflict between local statutory requirements and those of LR then the local requirements would take priority without necessarily affecting LR Classification, provided the structural strength and safety aspects are not compromised.

### 1.4 Interpretation of the Rules

1.4.1 The interpretation of the Rules is the sole responsibility, and at the sole discretion, of LR. Any uncertainty in the meaning of the Rules is to be referred to LR for clarification.

### 1.5 Client's responsibilities

1.5.1 It is the responsibility and the duty of the builder/main contractor to enable the Surveyors to satisfy themselves that the materials, workmanship and arrangements comply with the classification requirements by arranging for the Surveyors to be present at appropriate stages during the work and for presenting the items to be surveyed in such a way that the Surveyors are readily able to establish that all component/sub-component items have been manufactured, assembled, and tested in accordance with the appropriate requirements.

1.5.2 It is the responsibility of the Owners/operators, designer, builder and the installer to familiarize themselves with the appropriate sections of the Rules.

1.5.3 Survey procedures undertaken by LR when providing services are on the basis of periodical visits involving both monitoring and direct survey. However, LR's Surveyors will not be in continual attendance. Since construction and installation are continuous processes, the builder has the overall responsibility to ensure and document that the requirements of the Rules, approved drawings and any amendments agreed by the attending LR Surveyors have been complied with.

## ■ *Section 2*
## Withdrawal/Suspension of class

### 2.1 Withdrawal of class

2.1.1 When the class of a linkspan is withdrawn by the Committee in consequence of a request from the operators, the notation `Class withdrawn at Operator's request' (with date) will be assigned.

### 2.2 Suspension of class

2.2.1 When the Regulations for surveys on the structural components, equipment or engineering systems, as appropriate, have not been complied with and the linkspan is thereby not entitled to retain class, the class will be suspended, at the discretion of the Committee, and a corresponding notation will be assigned.

2.2.2 Class will be automatically suspended and the Certificate of Class will become invalid if the Annual or Intermediate Survey is not completed within three months of the due date of the survey.

2.2.3 Class will be automatically suspended from the expiry date of the Certificate of Class in the event that the Special Survey has not been completed by the due date and an extension has not been agreed (*see Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.8* and *Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.10*), or that the facility is not under attendance by the Surveyors with a view to completion of the survey prior to resuming operation.

2.2.4 When in accordance with *Pt 1, Ch 2, 4.6 Damages, repairs and alterations 4.6.3* a condition of class is imposed, a due date will be assigned for completion and the linkspan's class will be subject to a suspension procedure if the condition of class is not dealt with satisfactorily, or postponed by agreement, by the due date.

2.2.5 When it is found, from the reported condition of the structural components, equipment or machinery of a linkspan, that an operator has failed to comply with Regulations *Pt 1, Ch 2, 1.1 General 1.1.7 Pt 1, Ch 2, 4.6 Damages, repairs and alterations 4.6.1*, *Pt 1, Ch 2, 4.6 Damages, repairs and alterations 4.6.4* or *Pt 1, Ch 2, 4.6 Damages, repairs and alterations 4.6.5* the class may be suspended by the Committee, and a corresponding notation assigned. When it is considered that an operator's failure to comply with these requirements is sufficiently serious the suspension of class may be extended to include other linkspans controlled by the same operators, at the discretion of the Committee.

2.2.6 When it is found that a linkspan is being operated in a manner contrary to that agreed at the time of classification, i.e. outwith the approved design loadings and environmental conditions, the class may be suspended.

### 2.3 Recording Withdrawal/Suspension of class

2.3.1 In all instances of class withdrawal or suspension, the withdrawn or suspended class notation, with date of application, will appear in the *Maritime Guide*. In cases where class has been suspended by the Committee and it becomes apparent that the operators no longer intend to retain LR's class, the notation will be amended to withdrawn status. After class withdrawn status has been established in the *Maritime Guide* for one year, it will be automatically amended to `classed LR until' (with date).

## ■ *Section 3* Class characters and notations

### 3.1 General

3.1.1 This Section details the character symbols and notations which comprise the class assigned to linkspans.

3.1.2 The operational design conditions assigned to linkspans built and classed in accordance with the Rules will be issued as an appendix to the Classification Certificate and are to appear in the Operational Manual of the linkspan where such a Manual is required by the Rules.

### 3.2 Character symbols

3.2.1 All linkspans when classed, will be assigned a character of classification comprising one or more character symbols as applicable, e.g. ✠ **AT**.

3.2.2 A full list of character symbols for which craft may be eligible is as follows:

✠ = Signifies the linkspan has been constructed under LR's Special Survey and found to be in compliance with the Rules to the satisfaction of the Committee.

**A** = Signifies the linkspan has been found to have been built in accordance with LR's Rules and maintained in accordance with the Rules.

**T** = Signifies mooring or tethering equipment has been approved by LR as having been found in accordance with the Rules.

### 3.3 Class notations

3.3.1 In general, linkspans complying with the requirements of the Rules will be eligible for one of the following appropriate class notations:

✠ **AT** = Passenger Linkspan for service at.........'

✠ **AT** = Vehicle Linkspan for service at.........'

✠ **AT** = Passenger and Vehicle Linkspan for service at.........'

or for non-buoyant linkspans:

✠ **A** = Passenger Linkspan for service at.........'

✠ **A** = Vehicle Linkspan for service at.........'

✠ **A** = Passenger and Vehicle Linkspan for service at.........'

### 3.4 Other notations

3.4.1 ***IWS.** This notation (In-water Survey) may be assigned to a linkspan which has its underwater surfaces coated with an approved high resistant paint with a view to foregoing specific dry-docking survey requirements and where the applicable requirements of LR's Rules are complied with (*see Pt 1, Ch 3, 3.3 In-water Surveys*).

### 3.5 Descriptive note

3.5.1 In addition to any class notations, an appropriate descriptive note may be entered in column six of the *Maritime Guide* indicating the type of linkspan in greater detail than is contained in the class notation, and/or providing additional information about the linkspan's design and construction. This descriptive note is not an LR classification notation and is provided solely for the information of users of the *Maritime Guide*.

## ■ *Section 4* Surveys and certificates

### 4.1 Statutory surveys

4.1.1 LR will act, when authorized on behalf of Governments and requested to do so by Owners/operators, in respect of National and International statutory safety and other requirements.

### 4.2 New construction surveys

4.2.1 When it is intended to build a linkspan for classification with LR, application should be made to LR in writing. Constructional plans and all necessary particulars relevant to the structural aspects, equipment and machinery, where applicable, and as detailed in the Rules, are to be submitted before the work is commenced. Any proposals for subsequent modifications or additions to the scantlings, arrangements or equipment are to be submitted for approval before work commences.

4.2.2 Where the proposed design of a linkspan embodies the use of either materials or principles of structural arrangement (or of construction) which are without established successful precedent to an extent that the short and/or long term performance of the design cannot, in the opinion of LR, be predicted with confidence by conventional analytical methods, then special tests (which may include model tests) and/or examinations either before the commissioning of and/or during the early service life of the linkspan may be required. In such cases a suitable notation may be entered in the *Maritime Guide*.

4.2.3 The materials used in the construction of the linkspan and machinery intended for classification are to comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020* .

4.2.4 The Surveyor is to be satisfied that the capability, organizational systems and facilities of the builder and any sub-contractors are such that acceptable standards can be obtained both for the construction of the linkspan and the installation of machinery, hydraulic, electrical and control equipment.

4.2.5 New linkspans intended for classification are to be built and installed under LR's Special Survey. The Surveyors are to be satisfied that the materials, workmanship and arrangements at the locations of component manufacture and installation are in accordance with the Rules. Any items not in accordance with the Rules or the approved plans are to be brought to the attention of the attending Surveyors and rectified to their satisfaction.

4.2.6 For compliance with *Pt 1, Ch 2, 4.2 New construction surveys 4.2.5*, LR is prepared to consider methods of survey and inspection for construction which formally include partial reliance on defined procedures relating to the builder's management, organization and quality systems and thereby to those of the component manufacturers.

4.2.7 Copies of approved plans (showing the linkspan as built), essential certificates and records are to be made readily available for use when required by LR's Surveyors.

4.2.8 At key stages during component manufacture and installation, to be agreed with the builders, or their sub-contractors as appropriate, the linkspan is to be examined by the LR Surveyor and upon completion of installation the linkspan is to be examined by the LR Surveyor and tested as specified in the Rules.

4.2.9 All control equipment essential for the operation and/or safety of the linkspan is to be arranged, installed and tested in accordance with the Rules, as applicable.

4.2.10 The date of completion of the Special Survey during construction of linkspans built under LR's inspection will normally be taken as the date of build to be entered in the *Maritime Guide*. If the period between fabrication at the builders and completion of installation at the site is, for any reason, unduly prolonged, the dates of fabrication and completion of installation at the site may be separately indicated in the *Maritime Guide*.

4.2.11 A linkspan which is not put into commission within six months of completion may be re-examined before being put into service. If the condition is then found to be satisfactory, subsequent surveys will date from the time of such examination.

### 4.3 The first classification of existing linkspans not built under survey

4.3.1 When classification is desired for a linkspan not built under the supervision of LR's Surveyors, application should be made to LR in writing.

4.3.2 Information as detailed in *Pt 3, Ch 1, 8 Information required for approval* is to be submitted. If plans cannot be obtained or prepared by the operators, facilities are to be given for LR's Surveyors to obtain the necessary information from the linkspan.

4.3.3 Plans of the following items, where fitted, (plans of piping are to be diagrammatic) together with the particulars of the materials used in the construction of the air receivers and important forgings are to be submitted:

- General pumping arrangements, including air and sounding pipes.
- Bilge and ballast pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.
- Air receivers.
- Electrical circuits.
- Arrangement of compressed air systems.
- Arrangement of hydraulic systems.
- Ventilation arrangements of all enclosed spaces which require access.
- Remote and/or automatic controls for operating machinery.

4.3.4 Plans additional to those detailed in *Pt 1, Ch 2, 4.3 The first classification of existing linkspans not built under survey 4.3.3* need not be submitted unless the machinery is of a novel or special character affecting classification.

4.3.5 The survey requirements for linkspans which have not been built under LR's Survey are indicated in *Pt 1, Ch 3, 8 Initial classification of linkspans not built under survey*.

4.3.6 In the case of linkspans over 15 years of age, the requirements for classification of linkspans not built under survey will be specially considered.

### 4.4 Reclassification of existing linkspans

4.4.1 When reclassification or class reinstatement is desired for a linkspan for which the class previously assigned by LR has been withdrawn or suspended, the Committee will direct that a survey, appropriate to the age of the linkspan and the circumstances of the case, be carried out by LR's Surveyors. If, at such survey, the linkspan is found to be in accordance with the requirements of the Rules and Regulations, the Committee will be prepared to consider reinstatement of the original class or the assignment of such other class as may be deemed necessary. The date of any reclassification will be recorded in the *Maritime Guide*.

4.4.2 In the case of linkspans over 15 years of age, the requirements for reclassification will be specially considered.

4.4.3 The Committee reserves the right to decline an application for classification or reclassification where the prior history or condition of the linkspan indicates this to be appropriate.

### 4.5 Existing linkspans - Periodical Surveys

4.5.1 Linkspans are to be subjected to the periodical survey requirements as defined in *Pt 1, Ch 3 Periodical Survey Regulations*.

4.5.2 Annual Surveys are to be held on all linkspans within three months, before or after each anniversary of the completion, commissioning or Special Survey.

4.5.3 Docking or In-water Surveys are to be held on all floating or submerged elements of linkspans twice in a five year period and the maximum interval between successive surveys is not to exceed three years, and one of the two surveys required in a five year period should coincide with the Special Survey. Consideration may be given at the discretion of the Committee to any special circumstances justifying an extension of this interval.

4.5.4 Intermediate Surveys are to be held on all linkspans instead of the second or third Annual Survey after completion, commissioning or Special Survey.

4.5.5 The interval between Docking or In-water Surveys for linkspans operating in fresh water may, at the discretion of the Committee, be greater than that given in *Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.3*.

4.5.6 Attention is to be given by the operators to any relevant statutory requirements of the National Authority of the country in which the linkspan is sited.

4.5.7 Survey requirements for Docking or In-water Surveys are given in *Pt 1, Ch 3, 3 Docking Surveys and In-water Surveys - Structural and machinery requirements* as appropriate.

4.5.8 All linkspans classed with LR are also to be subjected to Special Surveys. The Surveys become due at five-yearly intervals, the first periodical Special Survey five years from the date of the first Special Survey during construction or date of the first Special Survey for Classification, and thereafter five years from the date for the previous Special Survey. Consideration can be given at the discretion of the Committee to any exceptional circumstances justifying an extension of the linkspan classification to a maximum of three months beyond the fifth year. If an extension is agreed, the next period of classification will start from the due date of the Special Survey before the extension was granted.

4.5.9 Special Surveys may be commenced at the fourth Annual Survey or fourth anniversary, as appropriate, after completion, commissioning or previous Special Survey, and be progressed during the succeeding year with a view to completion by the due date of the Special Survey.

4.5.10 Special Surveys which are commenced prior to their due date are not to extend over a period greater than 12 months, except with the prior approval of the Committee.

4.5.11 Linkspans which have satisfactorily passed a Special Survey will have a record entered in the *Maritime Guide* indicating the date. Where the Special Survey is completed more than three months before the due date, the new record of Special Survey will be the final date of survey. In all other cases the date recorded will be the fifth anniversary.

4.5.12 Complete Surveys of machinery become due at five yearly intervals, the first one five years from the date of build or date of first classification as recorded in the *Maritime Guide*, and thereafter five years from the date recorded in the *Maritime Guide* for the previous Complete Survey. Consideration can be given at the discretion of the Committee to any exceptional circumstances justifying an extension to a maximum of three months beyond the fifth year. If an extension is agreed to, the next period of machinery class will start from the due date of Complete Survey of machinery before extension was granted. Surveys which are commenced prior to their due date are not to extend over a period greater than 12 months, except with the prior approval of the Committee. On satisfactory completion of a Survey, an appropriate record will be made in the *Maritime Guide*. Where the Complete Survey is completed more than three months before the due date, the new date recorded will be the final date of survey. In all other cases the date recorded will be the fifth anniversary.

4.5.13 If it is found desirable that any part of the machinery should be examined again before the due date of the next survey, a certificate for a limited period will be granted in accordance with the nature of the case.

4.5.14 Linkspans covered by *Pt 1, Ch 2, 4.2 New construction surveys 4.2.2* may be subject to additional survey requirements. Such survey requirements will be detailed at the assignment of classification.

### 4.6 Damages, repairs and alterations

4.6.1 All repairs to the structure, equipment and machinery which may be required in order that a linkspan may retain class, (*see Pt 1, Ch 2, 1.1 General 1.1.7*), are to be carried out to the satisfaction of LR's Surveyors.

4.6.2 When at any survey the Surveyors consider repairs to be immediately necessary, either as a result of damage, or wear and tear, they are to communicate their recommendations at once to the operators, or their representative. When such recommendations are not complied with, immediate notification is to be given by the Surveyors to the Committee so that the class status of the installation may be considered.

4.6.3 When at any survey it is found that any damage, defect or breakdown (*see Pt 1, Ch 2, 1.1 General 1.1.7*) is of such a nature that does not require immediate permanent repair, but is sufficiently serious to require rectification by a prescribed date in order to maintain class, a suitable condition of class is to be imposed by the Surveyors and recommended to the Committee for consideration.

4.6.4 If a linkspan is to be moved from the service area under tow or by any other means and the operators wish the linkspan to remain in class, the operators are to advise LR prior to departure.

4.6.5 Plans and particulars of any proposed alterations to the approved scantlings and arrangements of the structure or machinery are to be submitted for approval to LR by the operators or builders or their representatives at the earliest opportunity, prior to the commencement of the alterations and such alterations are to be carried out to the satisfaction of LR's Surveyors.

### 4.7 Certificates

4.7.1 When the required reports, on completion of the survey of new or existing linkspans which have been submitted for classification, have been received from the Surveyors and approved by the Committee, a Certificate of First Entry of Classification,

signed by the Chairman, or the Deputy Chairman and Chairman of the Sub-Committee of Classification, will be issued to the Owners/operators.

4.7.2 A Certificate of Class valid for five years subject to endorsement for Annual and Intermediate Surveys, as appropriate, will also be issued to the operators after the satisfactory completion of each special survey.

4.7.3 LR's Surveyors are permitted to issue provisional (interim) certificates to enable a linkspan classed with LR to enter or continue in service provided that in their opinion it complies with the Rules. Such certificates will embody the Surveyors' recommendations for continuance of class, but all such certificates are subject to confirmation by the Committee.

### 4.8 Notice of surveys

4.8.1 It is the responsibility of the operators to ensure that all surveys necessary for the maintenance of class are carried out at the proper time and in accordance with the instructions of the Committee.

4.8.2 LR will give timely written notice to operators about forthcoming surveys. The omission of such notice, however does not absolve the operators from their responsibility to comply with LR's survey requirements for maintenance of class.

### 4.9 Survey of linkspans out of commission

4.9.1 Surveys for continuation of class may be required at the discretion of the Committee.

### 4.10 Appeal from Surveyors' recommendations

4.10.1 If the recommendations of LR's Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to the Committee, who may direct a Special Examination to be held.

### 4.11 Ownership details

4.11.1 The Owner will ensure a member of the LR Group - Marine and Offshore division is promptly informed in writing of any change to their contact details and, in the event of a vessel/asset transfer or sale, is to supply details of the new Owner in writing. The new Owner is to promptly inform a member of the LR Group - Marine and Offshore division in writing of their contact details. If the new Owner fails to do so and if LR cannot verify the ownership record, then the class of that vessel/asset will be specially considered by the Classification Committee.

## ■ *Section 5*
## IACS QSCS Audits

### 5.1 Audit of surveys

5.1.1 The surveys required by the Regulations may be subject to audit in accordance with the requirements of the International Association of Classification Societies Quality System Certification Scheme.

## ■ *Section 1* General

### 1.1 Frequency of surveys

1.1.1 The requirements of this Chapter are applicable to the Periodical Surveys set out in *Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys*. Except as amended at the discretion of the Committee, the periods between such surveys are as follows:

(a) Annual Surveys, as required by *Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.2*.
(b) Docking and In-water Surveys as required by *Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.3*.
(c) Intermediate Surveys as required by *Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.4*.
(d) Special Surveys at five-yearly intervals, *see Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.8*.
(e) Complete Surveys of machinery at five-yearly intervals, *see Pt 1, Ch 2, 4.5 Existing linkspans - Periodical Surveys 4.5.12*.

### 1.2 Surveys for damage or alterations

1.2.1 At any time when a linkspan is undergoing alterations or damage repairs, any exposed parts of the structure normally difficult to access are to be specially examined, e.g. if any part of the auxiliary machinery, insulation or fittings, is removed for any reason, the steel structure in way is to be carefully examined by the Surveyor, or when cement based screed in the bottom or covering on decks and/or ramps is removed, the plating in way is to be examined before the cement or covering is re-laid.

### 1.3 Unscheduled surveys

1.3.1 In the event that LR has cause to believe that its Rules are not being complied with, LR reserves the right to perform an unscheduled survey of the linkspan.

1.3.2 In the event of significant damage or defect affecting any linkspan, LR reserves the right to perform unscheduled surveys of the structure or machinery of any other similar linkspans classed by LR and deemed to be vulnerable.

### 1.4 Definitions

1.4.1 **A Ballast Tank** is a tank which is used primarily for salt-water, fresh water or permanent ballast.

1.4.2 **Spaces** are separate compartments such as holds and tanks.

1.4.3 **Enclosed space.** An enclosed space is any place of an enclosed nature where there is a risk of death or serious injury from hazardous substances or dangerous conditions. Examples include, but are not limited to: ballast tanks, double bottoms, double hull spaces, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, excavations and pits.

1.4.4 **Representative Spaces** are those which may be expected to reflect the condition of other spaces of similar type and service and with similar corrosion prevention systems.

1.4.5 **Critical Areas** are locations vulnerable to substantial corrosion, buckling and/or fatigue cracking, and single critical joints.

1.4.6 **Substantial Corrosion** is wastage of individual plates and stiffeners in excess of 75 per cent of allowable margins, but within acceptable limits.

1.4.7 **Protective Coatings** are to be hard coatings and are to be applied and maintained in compliance with the manufacturer's specification.

1.4.8 **Coating condition** of a specific area is defined as follows:

| | |
|---|---|
| GOOD: | minor spot rusting affecting not more than 20 per cent of the area. |
| FAIR: | local breakdown at edges of stiffeners and weld connections and/or light rusting affecting 20 per cent or more of the area. |
| POOR: | general breakdown of coating affecting 20 per cent or more of the area or hard scale affecting 10 per cent or more of the area. |

### 1.5 Preparation for survey and means of access

1.5.1 In order to enable the attending Surveyor(s) to carry out surveys, provisions for safe access and for surveys are to be agreed between the Owner and LR. Attention is drawn to the applicable recommendations in the IACS PR37 and/or IMO Recommendations For Entering Enclosed Spaces Aboard Ships, Resolution A.1050(27).

1.5.2 Means are to be provided to enable the Surveyor to examine the structure in a safe and practical way. Where the provisions of safety and required access are determined by the Surveyor not to be adequate, then the survey of the space(s) involved is not to proceed.

1.5.3 Spaces are to be made safe for access and survey and are to be sufficiently cleaned, illuminated and ventilated.

1.5.4 In preparation for survey, thickness measurements and to allow for a thorough examination, cleaning is to include removal from surfaces of all loose accumulated corrosion scale. Spaces are to be sufficiently clean and free from water, scale, dirt, and oil residues, etc. to reveal corrosion, deformation, fractures, damages or other structural deterioration, as well as the condition of the protective coating. However, those areas of structure whose renewal has already been decided by the Owner need only be cleaned and descaled to the extent necessary to determine the limits of renewed areas.

1.5.5 Where soft or semi-hard coatings have been applied, safe access is to be provided for the Surveyor to verify the effectiveness of the coating and to carry out an assessment of the conditions of internal structures which may include spot removal of the coating. When safe access cannot be provided, the soft or semi-hard coating is to be removed.

1.5.6 Prior to entering an enclosed space, it is to be verified by a competent person, using a calibrated multi gas meter, that the atmosphere in that space is free from hazardous gas and contains sufficient oxygen.

1.5.7 Emergency equipment and personnel are to be available in case of an emergency or rescue operation.

1.5.8 Information on procedures, equipment-operating instructions and safety checklists is to be available.

1.5.9 During the survey, ventilation is to be ensured and periodic testing is to be carried out as necessary to verify that the atmosphere remains safe for access.

## ■ *Section 2*
## Annual Surveys - Structural and machinery

### 2.1 General

2.1.1 Whenever practicable, Annual Surveys are to be held concurrently with statutory annual or other relevant statutory surveys, where these exist.

2.1.2 At Annual Surveys, the Surveyor is to examine the linkspan so far as necessary and practicable, in order to be satisfied as to its general condition. All critical areas are to be opened up for close examination as directed by the Surveyor, *see Pt 1, Ch 3, 2.2 Annual Surveys 2.2.5*.

### 2.2 Annual Surveys

2.2.1 The Surveyor is to confirm that the linkspan is operated at the specified location or within the general port area, as applicable, as defined by the class notation, for which it is currently approved.

2.2.2 The operators are to confirm to the Surveyor that vessels utilizing the linkspan do not exceed the maximum displacement or berthing speed and approach angles specified in the current approval. Operators are to provide evidence that the maximum displacement and approach speeds/angles have been communicated to the users of the installation.

2.2.3 The mooring or tethering arrangements are to be examined, as far as practicable, for all linkspans that have been assigned the class character symbol **T**.

2.2.4 The Surveyor is to confirm that, where provided, fendering arrangements continue to remain efficient.

2.2.5 In addition to the applicable requirements of *Pt 1, Ch 3, 2.2 Annual Surveys 2.2.1* to *Pt 1, Ch 3, 2.2 Annual Surveys 2.2.4*, the following are to be dealt with, where applicable:

(a) Examination of pontoon or other supporting structure, including internal bulkheads and watertight doors as applicable.
(b) Examination of bridges, ramps and walkways structures including end flaps and slides.
(c) Examination of vehicle running surfaces.
(d) Examination of bridges, ramps and walkways hinge arrangements, pivot pins and slewing bearings including bankseat bearings, and any flap hinge arrangements.
(e) Examination of sheaves, sprockets, guide rollers, axle pins and bearings forming a part of any ramp lifting arrangement.
(f) Examination of winches, hydraulic cylinders and attachments forming a part of any ramp lifting arrangement.
(g) Examination of operating locks, stowage locks, and safety guards including any associated hydraulic systems.
(h) Examination of wire ropes forming a part of any ramp lifting arrangement.
(i) Examination of chains forming a part of any ramp lifting arrangement.
(j) Examination of shackles and links forming a part of any ramp lifting arrangement.
(k) Examination of rope drums forming a part of any ramp lifting arrangement including the rope attachment to them.
(l) Examination of mooring arm structures, hinge arrangements, link pins and pontoon or quay mounted supporting structure.
(m) Verification by operational test of the efficient safe working of lifting appliances and hydraulic systems.
(n) Verification by operational test of any passenger and/or vehicle control barriers at access points to the linkspan.
(o) Verification by operational test of the pumps and piping systems for bilge and ballast arrangements. The piping systems and associated valves are to be examined as far as is practicable.
(p) Examination of air venting and sounding arrangements for all tanks.
(q) The condition of the electrical equipment and cabling is to be examined under operating conditions so far as is practicable.

## ■ *Section 3*
## Docking Surveys and In-water Surveys - Structural and machinery requirements

### 3.1 General

3.1.1 At Docking Surveys or In-water Surveys the Surveyor is to examine the linkspan and auxiliary machinery, where fitted, so far as necessary and practicable, in order to be satisfied as to the general condition. *See also Pt 1, Ch 3, 6 Machinery surveys - General requirements*.

3.1.2 The requirements of this Section are not applicable to any linkspan which derives its inherent primary support from non-buoyant means only.

### 3.2 Docking Surveys

3.2.1 Where a linkspan is in dry-dock or on a slipway it is to be placed on blocks of sufficient height, and proper staging is to be erected as may be necessary, for the examination of the shell including bottom plating.

3.2.2 Attention is to be given to those parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing and lying on the ground or sea-bed and to any undue unfairness of the plating of the bottom.

3.2.3 The sea connections and overboard discharge valves, where fitted, and their attachments to the pontoon and the gratings at the sea inlets are to be examined.

3.2.4 Where provided, chain cables are to be ranged, and examined by the Surveyor (*see also Pt 1, Ch 3, 5.3 Examination and testing 5.3.9* and *Table 3.5.1 Survey preparation*).

**3.3 In-water Surveys**

3.3.1 An In-water Survey is to provide the information normally obtained from the Docking Survey, so far as is practicable.

3.3.2 Proposals for In-water Surveys are to be submitted in advance of the survey being required so that satisfactory arrangements can be agreed with LR.

3.3.3 The In-water Survey is to be carried out under the surveillance of an LR Surveyor, with the linkspan at a suitable draught in sheltered waters; the in-water visibility is to be good and the structure below the waterline is to be clean. The Surveyor is to be satisfied that the method of pictorial presentation is satisfactory. There is to be good two-way communication between the Surveyor and the diver.

3.3.4 The In-water Survey is to be carried out by a qualified diver employed by a firm approved by LR. In addition, for certain aspects of the In-water Survey, consideration may be given to the use of a Remotely Operated Vehicle (ROV) operated by the LR approved firm.

3.3.5 If the In-water Survey reveals damage or deterioration that requires early attention, the Surveyor may require that the linkspan be dry-docked in order that a more thorough survey can be undertaken and the necessary remedial work carried out.

3.3.6 Where a linkspan has an ***IWS** notation, the condition of high resistant paint is to be confirmed in order that the ***IWS notation** can be maintained.

3.3.7 Some National Administrations may have requirements additional to those of *Pt 1, Ch 3, 3.3 In-water Surveys 3.3.1* to *Pt 1, Ch 3, 3.3 In-water Surveys 3.3.6*.

3.3.8 For linkspans where In-water Surveys are carried out the following are to be dealt with:

(a) The requirements for In-water Surveys are to be carried out as far as practicable taking due account of any limitations due to reduced access or visibility at the specified service location.
(b) The condition of the high resistant paint is to be confirmed. The Surveyor may require the linkspan to be dry-docked for maintenance of the high resistant paint coating of the underwater portion of the hull where any deterioration is found.
(c) A survey of all salt-water ballast and buoyancy tanks is required. Where protective coatings are found to be in GOOD condition as defined in *Pt 1, Ch 3, 1.4 Definitions 1.4.8* the extent of the survey may be specially considered. The internal surfaces of the underwater portion of the shell plating are to be examined.
(d) The condition of protective coatings in all salt-water ballast and buoyancy tanks is to be confirmed. Where a protective coating is found to be in POOR condition as defined in *Pt 1, Ch 3, 1.4 Definitions 1.4.8* and it has not been repaired, or where a protective coating was not applied from the time of construction, maintenance of class will be subject to the spaces in question being internally examined and gauged as necessary at Annual Surveys.
(e) The mooring or tethering arrangements are to be examined for all linkspans that have been assigned the class character symbol **T**. Where mooring and tethering arrangements are confined to above water structures and fittings, an examination is also to be carried out of any shore mounted structures, including any bankseat bearings which form an inherent part of these arrangements. Where mooring and tethering arrangements include guidepiles and yokes, the yokes are to be examined. The Surveyor may require underwater mooring ropes or chains to be lifted in order to ascertain their condition by opening out or gauging as appropriate.

## ■ *Section 4*
## Intermediate Surveys - Structural and machinery requirements

**4.1 General**

4.1.1 Whenever practicable, Intermediate Surveys are to be held concurrently with statutory annual or other relevant statutory surveys, where these exist.

### 4.2 Intermediate Surveys

4.2.1 The requirements of *Pt 1, Ch 3, 2 Annual Surveys - Structural and machinery* are to be complied with where appropriate.

4.2.2 A General Examination of salt-water ballast and buoyancy tanks is to be carried out as required by *Pt 1, Ch 3, 4.2 Intermediate Surveys 4.2.4*and *Pt 1, Ch 3, 4.2 Intermediate Surveys 4.2.5*. If such examinations reveal no visible structural defects then the examination may be limited to a verification that the protective coating remains in GOOD or FAIR condition as defined in *Pt 1, Ch 3, 1.4 Definitions 1.4.8*. When considered necessary by the Surveyor thickness measurement of the structure is to be carried out.

4.2.3 For salt-water ballast and buoyancy tanks, where a protective coating is found to be in POOR condition, as defined in *Pt 1, Ch 3, 1.4 Definitions 1.4.8*, where a soft coating has been applied or where no protective coating has been applied from the time of construction, maintenance of class will be subject to the spaces in question being internally examined and gauged as necessary at Annual Surveys.

4.2.4 For all linkspans over five years of age and up to 10 years of age, representative salt-water ballast and buoyancy tanks are to be examined. For tanks, where a protective coating is found in POOR condition, as defined in *Pt 1, Ch 3, 1.4 Definitions 1.4.8*, or other defects are found, where a soft coating has been applied or where a protective coating was not applied from the time of construction, the examination is to be extended to other ballast tanks of the same type.

4.2.5 For all linkspans over 10 years of age, all salt-water ballast and buoyancy tanks are to be examined.

4.2.6 The Surveyor is to carry out a survey and thickness measurements of any structure identified at the previous Special Survey as having substantial corrosion.

## ■ *Section 5*
## Special Survey - Structural requirements

### 5.1 General

5.1.1 The survey is to be of sufficient extent to ensure that the linkspan and related piping, where appropriate, is in satisfactory condition, subject to proper maintenance and operation and to periodical surveys being carried out as required by the Regulations.

5.1.2 The requirements of *Pt 1, Ch 3, 2 Annual Surveys - Structural and machinery* are to be complied with as applicable for all linkspans.

5.1.3 A Docking or In-water Survey in accordance with the requirements of *Pt 1, Ch 3, 3 Docking Surveys and In-water Surveys - Structural and machinery requirements* is to be carried out as part of the Special Survey.

**Table 3.5.1 Survey preparation**

| Periodical Special Survey I and II (Linkspans up to 10 years old) | Periodical Special Survey III and subsequent (Linkspans 15 years old and over) |
|---|---|
| (1) All spaces are to be cleared and cleaned as necessary to allow proper examination. Suitable access platforms etc. are to be provided as required. Where necessary, lining and pipe casings are to be removed for examination<br><br>(2) The steelwork is to be exposed and cleaned and rust removed as may be required for its proper examination by the Surveyor<br><br>(3) All tanks are to be cleaned as necessary to permit examination, where this is required by *Table 3.5.2 Tank internal examination requirements*<br><br>(4) Casings or covers of air, sounding and other pipes and linings in way of sheel penetrations are to be removed, as required by Surveyor | In addition the requirements for Special Survey II, the following are to be complied with:<br><br>(1) Portions of wood sheathing, or other covering on steel decks and/or ramps are to be removed, as considered necessary by the Surveyor, in order to ascertain the condition of the plating |

| | |
|---|---|
| (5) Bearings, sheaves, sprockets, guide rollers, axle pins, pintles and hinges are to be opened up as required by the Surveyor<br><br>(6) At Special Survey II the chain locker, where provided, is to be cleaned internaly for examination. The chain cables and/or other tethering components are to be ranged for inspection | |

**Table 3.5.2 Tank internal examination requirements**

| Tank | Periodical Special Survey I (Linkspans 5 years old) | Periodical Special Survey II (Linkspans 10 years old) | Periodical Special Survey III (Linkspans 15 yeras old) | Periodical Special Survey IV (Linkspans 20 years old) | All subsequent Periodical Special Surveys |
|---|---|---|---|---|---|
| Salt water ballast tanks | All tanks | All tanks | All tanks | All tanks | All tanks |
| Fresh water | None | *See* Note 1 | *See* Note 2 | *See* Note 3 | All tanks |
| Hydraulic oil/oil tanks where fitted | None | *See* Note 1 | *See* Note 2 | *See* Note 3 | All tanks |
| Note 1. Tanks used exclusively for fresh water ballast, or hydraulic oil or other oil need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing and from an internal examination of the after end of one forward tank, and one selected deep tank.<br><br>Note 2. Tanks used exclusively for fresh water ballast, or hydraulic oil or other oil need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing and from an internal examination of one forward tank, one aft and one selected deep tank.<br><br>Note 3. Tanks used exclusively for fresh water ballast, or hydraulic oil or other oil need not all be examined internally provided that the Surveyor is satisfied with the condition, after both external examination and testing and from an internal examination of at least one tank amidships, one forward, one aft and one deep tank. | | | | | |

**Table 3.5.3 Thickness measurement**

| Periodical Special Survey I (Linkspans 5 years old) | Periodical Special Survey II (Linkspans 10 years old) | Periodical Special Survey III and subsequent (Linkspans 15 years old and over) |
|---|---|---|
| (1) Critical areas, as required by the Surveyor | (1) Critical areas, as required by the Surveyor | (1) Selected areas of ramp, bridges, walkways and super-structure plating<br><br>(2) Wind and water strakes throughout<br><br>(3) Side shell plating and frames in way of ballast tanks<br><br>(4) Other critical areas, as required by the Surveyor |

### 5.2 Preparation

5.2.1 The linkspan is to be prepared for overall survey in accordance with the requirements of *Table 3.5.1 Survey preparation*, where appropriate. The preparation should be of sufficient extent to permit as clear a view as reasonably practicable of corrosion, fractures, or other damages apparent on visual examination.

### 5.3 Examination and testing

5.3.1 All spaces within the linkspan are to be examined where appropriate.

5.3.2 In certain circumstances the internal examination of fresh water and hydraulic/oil tanks, where appropriate, may be waived. For the minimum extent of tank internal examination, *see Table 3.5.2 Tank internal examination requirements*.

5.3.3 For salt-water ballast and buoyancy tanks, where a protective coating is found in POOR condition as defined in *Pt 1, Ch 3, 1.4 Definitions 1.4.8* and it is not renewed, where a soft coating has been applied or where no protective coating has been

applied from the time of construction, maintenance of class will be subject to the space in question being internally examined and gauged as necessary at Annual Surveys.

5.3.4 All tanks are to be tested by a head sufficient to give the maximum pressure that can be experienced in service. Tanks may be tested afloat provided that their internal examination is also carried out afloat.

5.3.5 Where repairs are effected to the shell plating or bulkheads, any tanks in way are to be tested to the Surveyor's satisfaction on completion of these repairs.

5.3.6 In cases where the inner surface of the bottom plating is covered with cement, asphalt, or other composition, the removal of this covering may be dispensed with, provided that it is inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

5.3.7 All decks and/or ramps, bridges, walkways and associated fittings, casings and superstructures are to be examined.

5.3.8 Wood decks or sheathing, if fitted, are to be examined; if decay or rot is found or the wood is excessively worn the wood is to be renewed. When a wood deck, laid on stringers and ties, has worn by 20 per cent or more, it is to be renewed. Attention is to be given to the condition of the plating under wood decks, sheathing or other deck and/or ramp covering. If it is found that such coverings are broken, or are not adhering closely to the plating, sections are to be removed as necessary to ascertain the condition of the plating. (*See also Pt 1, Ch 3, 1.2 Surveys for damage or alterations 1.2.1*).

5.3.9 Where provided, the mooring and tethering systems are to be examined. If any length of chain cable is found to be reduced in mean diameter at its most worn part by 12 per cent or more from its nominal diameter, it is to be renewed.

5.3.10 Watertight doors, air and sounding pipes, as appropriate, are to be examined and operationally tested as applicable.

### 5.4 Thickness measurement

5.4.1 The Surveyor may require to measure the thickness of the material in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or excessively reduced in scantlings are to be made good by materials of the approved scantlings and quality. Attention is to be given to the structure in way of discontinuities.

5.4.2 The minimum requirements for thickness measurement are given in *Table 3.5.3 Thickness measurement*.

5.4.3 Thickness measurements are normally to be by means of ultrasonic test equipment and are to be carried out by a firm qualified as Grade 1 or Grade 2 according to Lloyd's Register *Approval for Thickness Measurement of Hull Structures*.

5.4.4 The degree of supervision or check testing by the Surveyor is dependent upon the grade of approval extended to the firm carrying out the thickness measurements:

(a) The work of firms having Grade 1 approval is subject to check testing by the Surveyor.
(b) Thickness measurements by firms having Grade 2 approval is to be carried out with the Surveyor substantially in attendance.

5.4.5 Thickness measurements may be carried out in association with the fourth Annual Survey.

5.4.6 The Surveyor may extend the scope of thickness measurement if deemed necessary.

### 5.5 Thickness measurement reporting

5.5.1 A report is to be prepared by the approved firm carrying out the thickness measurement. The report is to give the location of measurement, the thickness measured as well as the corresponding original thickness. The report is to give the date when the measurement was carried out, the type of measuring equipment, names of personnel and their qualifications and is to be signed by the operator and supervisor.

5.5.2 The thickness measurement report is to be verified and signed by the Surveyor.

## Section 6
## Machinery surveys - General requirements

### 6.1 Annual, Intermediate and Docking Surveys and In-water Surveys

6.1.1 The requirements of *Pt 1, Ch 3, 2 Annual Surveys - Structural and machinery Pt 1, Ch 3, 3 Docking Surveys and In-water Surveys - Structural and machinery requirements* and *Pt 1, Ch 3, 4 Intermediate Surveys - Structural and machinery requirements* are to be complied with as applicable.

### 6.2 Complete Surveys

6.2.1 Provision is to be made for the capability to blank off temporarily all sea openings. At Complete Surveys, all openings to the sea are to be examined together with any valves, cocks and fastenings connected with them.

6.2.2 Where installed, the following machinery and components are also to be examined:

(a) Engines, air compressors with their intercoolers, filters and/or oil separators and safety devices, and all pumps and components used for operational services.
(b) Winches and associated lifting equipment, where fitted.

6.2.3 All air receivers for operational services, where fitted, together with their mountings, valves and safety devices, are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to 1,3 times the working pressure.

6.2.4 The valves, cocks and strainers of the bilge systems, where fitted, are to be opened up as considered necessary by the Surveyor and together with pipes, are to be examined and tested under working conditions. All safety devices for the foregoing items are to be examined as appropriate.

6.2.5 Hydraulic oil connections, together with all filters, used for operational services are to be opened up and examined or tested, as considered necessary by the Surveyor. All safety devices for the foregoing items are to be examined as appropriate.

6.2.6 Ballast connections, together with all filters, used for operational services are to be opened up and examined or tested, as considered necessary by the Surveyor. All safety items for the foregoing items are to be examined as appropriate.

6.2.7 All controls and alarms fitted which are essential for the operation and/or safety of the linkspan are to be tested to demonstrate that they are in good working order.

## Section 7
## Electrical equipment surveys

### 7.1 Annual and Intermediate Surveys

7.1.1 The requirements of *Pt 1, Ch 3, 2.2 Annual Surveys*and *Pt 1, Ch 3, 4.2 Intermediate Surveys* are to be complied with as far as applicable.

### 7.2 Complete Surveys

7.2.1 An electrical insulation resistance test is to be made on the electrical equipment and cables. The installation may be sub-divided or equipment, which may be damaged, disconnected for the purpose of this test.

7.2.2 The fittings on the main switchboard, section boards and distribution boards, where fitted, are to be examined and over-current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

7.2.3 Circuit-breakers, where fitted, are to be tested, so far as is practicable, to verify that protective devices including preference tripping relays, if fitted, operate satisfactorily.

7.2.4 The electric cables, where fitted, are to be examined, so far as is practicable, without undue disturbance of fixtures or casings unless opening up is considered necessary as a result of observation or of the tests required by *Pt 1, Ch 3, 7.2 Complete Surveys 7.2.1*.

7.2.5 Navigation light indicators, where fitted, are to be tested under working conditions, and correct operation on the failure of supply or failure of navigation lights verified.

7.2.6 A General Examination of the electrical equipment, as appropriate, in areas which may contain flammable gas or vapour and/or combustible dust is to be made to ensure that the integrity of the safe type electrical equipment has not been impaired owing to corrosion, missing bolts, etc. and that there is not an excessive build-up of dust on or in dust protected electrical equipment. Cable runs are to be examined for sheath and armouring defects, where practicable, and to ensure that the means of supporting the cables are in good order. Tests are to be carried out to demonstrate the effectiveness of bonding straps for the control of static electricity. Alarms and interlocks associated with pressurized equipment or spaces are to be tested for correct operation.

## ■ *Section 8*
## Initial classification of linkspans not built under survey

### 8.1 General

8.1.1 Periodical Surveys of such a linkspan, when classed, are subsequently to be held as in the case of linkspans built under survey.

### 8.2 Structure

8.2.1 In all cases the full requirements of *Pt 1, Ch 3, 5 Special Survey - Structural requirements Pt 1, Ch 3, 6 Machinery surveys - General requirements*, and *Pt 1, Ch 3, 7 Electrical equipment surveys* are to be carried out as applicable. Linkspans of recent construction will receive special consideration.

8.2.2 During the survey, the Surveyors are to satisfy themselves regarding the workmanship and verify the approved scantlings and arrangements. For this purpose, and in order to ascertain the amount of any deterioration, parts of the structure will require to be gauged as necessary. Full particulars of the mooring or tethering arrangements are to be submitted, where provided.

8.2.3 When the full survey requirements indicated in *Pt 1, Ch 3, 8.2 Structure 8.2.1*and *Pt 1, Ch 3, 8.2 Structure 8.2.2* cannot be completed at one time, the Committee may consider granting an interim certificate for a limited period. The conditions regarding the completion of the survey will depend on the merits of each particular case, which should be submitted for consideration.

### 8.3 Machinery

8.3.1 The machinery, hydraulic oil and compressed air pipes are to be examined as required at Complete Surveys. Working pressures are to be determined from the actual scantlings in accordance with the Rules.

8.3.2 The bilge and ballast arrangements are to be examined and amended, as necessary, to comply with the Rules.

8.3.3 The electrical equipment is to be examined as required at Complete Surveys.

8.3.4 The whole of the machinery, including essential controls and alarms, is to be tested under working conditions to the Surveyor's satisfaction.

# Contents

## Section 1
## Rules for the Manufacture Testing and Certification of Materials

### 1.1 Reference

Please see *Rules for the Manufacture, Testing and Certification of Materials, July 2020*

# Contents

## ■ *Section 1* Application

### 1.1 General

1.1.1 In general the Rules apply to linkspans as defined in *Pt 1, Ch 2, 1.2 Application 1.2.1*, constructed of steel or aluminium alloys.

1.1.2 Linkspans specifically designed for similar purposes, or constructed in other materials may also be considered based on the general standards of the Rules.

### 1.2 Exceptions

1.2.1 The Rules cover only those aspects of safety which are explicitly or implicitly embodied in them. They do not cover any other technical or operational characteristics of linkspans, such as the intact and damage stability of pontoons, vibration, towage and the potential for environmental pollution. *See also Pt 1, Ch 2, 1.2 Application 1.2.1* and *Pt 1, Ch 2, 1.3 Scope of classification 1.3.4* regarding interface components.

## ■ *Section 2* Structural calculations

### 2.1 General

2.1.1 The Rules embody structural requirements for linkspans and have been developed to enable adequate regulatory evaluation by normal methods of structural analysis on the basis that:

(a) The wave induced loads and load variations on the structural components are not of an excessive order during normal operations, and: Should the wave induced loads and load variations (relative to the response sensitivities to these loads of the proposed structure) be envisaged by the designer or by LR as being of a sufficiently high order, then suitable model tests or, if feasible, advanced mathematical hydrodynamic analyses are to be carried out to determine their magnitudes. (*See Pt 1, Ch 2, 4.2 New construction surveys 4.2.2*), and
(b) The structural complexity of the proposed arrangements is limited: Should, in the judgement of the designer or of LR, the proposed structural arrangements be too complex for normal methods of analysis in use, then direct calculations using advanced structural analysis techniques, for example, finite element analyses, are to be carried out. In such cases the acceptance criteria are to be as for normal methods of analysis unless specially agreed otherwise by LR and the calculations are to comply with the following requirements.

2.1.2 Where direct calculations are carried out the following details are to be submitted:

(a) a description of the calculation logic and the procedures used, together with the name of any computer program used. Reference should also be made to *Pt 3, Ch 1, 3.1 Alternative arrangements and scantlings 3.1.2*;

(b) diagrams of structural modelling;

(c) a summary of analysis parameters including component sectional properties, boundary conditions, and means of applying the loads;

(d) a schedule of load cases including a summary of input data for each;

(e) a sufficiently comprehensive summary of output.

2.1.3 In general, it will not be necessary to submit large volumes of input and output data associated with programs such as finite element analysis unless specifically requested.

2.1.4 The responsibility for specification and input of program data, and the subsequent transcription of output, together with the integrity of the program, rests with the Designer.

## ■ *Section 3* **Equivalents**

### 3.1 Alternative arrangements and scantlings

3.1.1 In addition to cases where direct calculations are required by *Pt 3, Ch 1, 2.1 General 2.1.1*, LR will consider alternative scantlings for pontoon structures which have been derived by direct calculations in lieu of the prescriptive Rule requirements. All direct calculations are to be submitted for examination including the associated load evaluations. The acceptance criteria are to be equivalent to those embodied in the Rules.

3.1.2 LR will consider the use of Designers' programs for direct calculations where it can be established that the program has been properly validated and has previously given satisfactory results when used to perform direct calculations.

## ■ *Section 4* **National Regulations**

### 4.1 General

4.1.1 LR, when authorized, will act on behalf of Governments and, if requested, will certify compliance in respect of any appropriate National requirements.

## ■ *Section 5* **Inspection and workmanship**

### 5.1 Inspection

5.1.1 Adequate means are to be provided to enable the Surveyor to carry out a satisfactory inspection of all components during each stage of prefabrication, construction and installation.

### 5.2 Workmanship

5.2.1 All workmanship is to be in accordance with good engineering practice and such that it meets the requirements of the Rules. Unacceptable defects are to be rectified to the satisfaction of the Surveyor before the material is covered with paint, or other coating. The materials and welding are to be in accordance with the requirements of *Rules for the Manufacture, Testing and Certification of Materials, July 2020*. The assembly sequence and welding sequence are to be agreed prior to construction and to

be to the satisfaction of the LR Surveyor. Plates which have been subjected to excessive heating may be liable to rejection or, exceptionally, may be satisfactorily heat treated before being incorporated into the structure.

## ■ *Section 6*
## Acceptance testing of pontoons, bridges, ramps and walkways

### 6.1 Pontoons

6.1.1 **Hose testing.** Any watertight doors, bulkheads, tunnels or weathertight deck closures are to be pressure hose tested, with a hose supply pressure of at least 0,2 MPa, from a maximum distance of 1,5 m, to the Surveyor's satisfaction.

6.1.2 **Pressure testing.** Water ballast tanks are to be pressure tested to a 2,40 m head above the highest point of the tank, excluding hatchway, or to the top of the overflow, whichever is the greater.

6.1.3 **Leak testing.** Leak testing is required on fillet weld connections on tank boundaries. This test is also required on erection welds on tank boundaries except for welds made by automatic processes. Selected locations of automatic erection welds and pre-erection manual or automatic welds may be required to be similarly tested at the discretion of the Surveyor taking account of the quality control procedures operating in the yard. This test is carried out by applying a soapy water solution to the weld being tested while the tank is subjected to an air pressure of 0,015 MPa. It is recommended that, with a minimum number of personnel in the vicinity of the tank, the air pressure in the tank is raised to 0,02 MPa and kept at this level for about one hour to reach a stabilized state, and then lowered to the test pressure prior to inspection. Leak testing is to be carried out before a protective coating is applied.

6.1.4 When a protective coating is to be applied to the internal structure of a tank, the water test may take place after the application of the coating, provided that the structure is carefully examined to ensure that welding and structural stiffening are completed prior to the application of the coating, excluding prefabrication primers. The cause of any discolouration or disturbance of the coating is to be ascertained and any deficiencies repaired.

6.1.5 Pressure testing may be carried out afloat where testing using water cannot be accommodated in dry-dock or on the building site. The testing afloat is to be carried out by separately filling each tank and cofferdam to the test head given in *Pt 3, Ch 1, 6.1 Pontoons 6.1.2*.

6.1.6 Alternative proposals for testing will be considered.

### 6.2 Bridges, ramps and walkways

6.2.1 Each bridge or walkway span and every ramp span is to be proof tested in its working position by applying appropriate test loads after installation, and following any major repair, renewal or modification to help verify compliance of the structure and its support arrangements with the Rule requirements. Testing is to be carried out throughout high and low tide conditions to allow for the dynamic effects of tidal movement. It should be noted that testing does have some limitations for verifying structural integrity and will not verify fatigue strength.

6.2.2 The magnitude of the proof test load, $T$, is to be based on the applied design load, $W$, in tonnes, of the bridge, ramp or walkway section derived from the design UDL x working area, or in the case of ramps and bridges the maximum vehicle load or SWL, as follows:

$$T = 1{,}25W \text{ for } W \leq 20 \text{ t}$$

$$T = W + 5{,}0 \text{ t where } 20 \text{ t} < W \leq 50 \text{ t}$$

$$T = 1{,}1W \text{ where } W > 50 \text{ t}$$

A concentrated load equivalent to a UDL, or vice versa, may be used where appropriate.

6.2.3 Additionally, bridges, ramps and walkways that are raised or lowered when unloaded are to be proof tested to the satisfaction of the Surveyor after installation and after major repair, renewal or alteration as follows:

(a) The brake or other mechanism, if fitted, is to hold the bridge, ramp or walkway in its most unfavourable position whilst carrying an additional test load equal to 25 per cent of its self weight. The test load is to be evenly distributed over the working surface where this is practicable.

(b) Any part of the linkspan which may be mechanically hoisted or lowered is also to be operated through at least one complete operating cycle.

6.2.4 Alternative proposals for testing will be considered.

## ■ Section 7 Towage certificate

### 7.1 General

7.1.1 When a towage certificate is requested by the Builder or operators to cover the linkspan while being towed at sea, the scantlings and arrangements will be considered separately.

## ■ Section 8 Information required for approval

### 8.1 General

8.1.1 Before plan approval can commence, the information detailed in this section relating to the site at which the linkspan will operate is to be submitted for consideration.

### 8.2 Environmental data

8.2.1 All data reflecting the environment in which the linkspan is designed to operate, and which it will experience at its service site are to be submitted. These data include:

(a) Large scale hydrographic chart of the local area, its seabed topography and its environs.
(b) Highest and lowest astronomical tides (HAT and LAT) together with details of known exceptional water levels for the site location and the associated return period.
(c) Maximum operating and survival wind speeds and directions associated with a 50 year return period for the site.
(d) Maximum and operational significant wave heights and periods and directions associated with a 50 year return period for the site. Information also to include the effects of waves from passing marine craft.
(e) Maximum current speeds and directions at site including the effects of ships' propulsion units.
(f) Seabed conditions and likelihood of silting in vicinity of site.
(g) The anticipated effects of passing marine craft at site.
(h) For areas subject to sub-zero temperatures the lowest observed daily mean ambient temperature (LODMAT) for the location is to be submitted. *See Pt 3, Ch 2, 2.1 Grades of steel 2.1.2*.
(i) Extreme snow and ice loadings.
(j) Seismic conditions, where appropriate.

### 8.3 Operational data

8.3.1 Vehicle loading data on ramps, bridges and pontoon decks including:

(a) Maximum gross vehicle weight with maximum axle loads, associated axle spacings and tyre print data.
(b) Number of vehicles assumed to be present on the linkspan, loading rate and fatigue load spectrum.
(c) Number of traffic lanes and direction of traffic.
(d) Exceptional vehicle loading, including any tracked vehicles or other loadings specified by the Designer.
(e) Range of height adjustment. Maximum ramp gradients, operational and extreme.
(f) Vertical geometry profile of ramps at ship to ramp interface and at other points of articulation.

8.3.2 Other applied loading data:

(a) Design uniformly distributed loadings.

(b) Loads imposed by ships' ramps including location on berthing face.
(c) Passenger/pedestrian loadings.
(d) Any other loadings not specified above.

8.3.3 Berthing data including:

(a) Size and displacement of ships intending to use the linkspan.
(b) Berthing contact speeds and approach angles.
(c) Proposed mode of berthing and means of the ship's position-keeping when berthed.
(d) Frequency of berthings and Designer's calculations of berthing energy.

8.3.4 Other operational data:

(a) Coefficients of friction for all sliding support surfaces of bridges, ramps and walkways.
(b) Maximum inclinations of bridges, ramps and walkways during operation.

### 8.4 Pontoon structural data

8.4.1 The following plans and information are to be submitted for approval:

(a) Profile and deck(s).
(b) Shell plating and stiffening arrangements.
(c) Sections showing transverse and longitudinal structural members.
(d) All transverse and longitudinal bulkheads.
(e) Details of appendages fixed to the pontoon supporting bridges, ramps and walkways.
(f) Pillars (where fitted).
(g) Welding and construction details.
(h) Material grades used in the construction.
(i) Mooring and towing attachments.
(j) Fixed and adjustable ballasting and sounding arrangements. (*See also Pt 3, Ch 1, 8.7 Other information 8.7.1*).
(k) Locations and weights or loadings from all equipment, fixed or otherwise, which may affect buoyancy calculations.

8.4.2 The following plans and/or information are to be submitted for information purposes where applicable:

(a) General arrangement.
(b) Hydrostatic properties.
(c) Maximum design operating angles of heel and trim.
(d) Maximum amplitude of dynamic wave-induced pontoon roll and pitch in service.

### 8.5 Vehicle ramps, bridges, walkways and structural steelwork data

8.5.1 Plans indicating the following information are to be submitted for approval:

(a) All structural plans, including details of deck plating, deck longitudinals, transverses, girders and any gantries or supporting columns and towers where provided.
(b) Material specifications.
(c) All hinges and articulated joints.
(d) All support arrangements.
(e) Details of all connections including weld sizes and number, size and grade of bolts where fitted.
(f) All hoisting arrangements, where applicable, including reeving arrangements, rope sizes and sheave details, and hydraulic cylinders and associated schematics.

8.5.2 The following plans are to be submitted for information where applicable:

(a) General arrangement, including the positions of any bridge, ramp or walkway at the lowest and highest tides and showing allowances ensuring the linkspan will not foul any obstacle within the operating envelope.

### 8.6 Mooring and tethering arrangements

8.6.1 Details of the method of securing the linkspan pontoon on-station are to be submitted. *See Pt 1, Ch 2, 1.2 Application 1.2.1*and *Pt 1, Ch 2, 1.3 Scope of classification 1.3.4*.

8.6.2 Details of the mooring system (including size, material grade and design loads of ropes, chain cables, shackles, etc.) and of the tethering components (e.g. guidepiles, yokes, brackets, etc.) are to be submitted for approval.

### 8.7 Other information

8.7.1 Pontoon ballasting arrangements and maximum and minimum ballast drafts are to be indicated for the operating condition and, where applicable, towage conditions. Where ballasting is adjusted using compressed air, the maximum air pressure is to be specified. The envisaged maximum static angles of heel and trim, are also to be specified.

8.7.2 All test procedures are to be submitted in accordance with *Pt 3, Ch 1, 6 Acceptance testing of pontoons, bridges, ramps and walkways*.

8.7.3 Where an impressed current cathodic protection system is fitted, plans showing the proposed layout of anodes, reference cells and wiring diagrams are to be submitted.

8.7.4 The results of any model tests are to be submitted.

8.7.5 The design life of the linkspan is to be advised. A fatigue assessment in accordance with a recognized National or International Standard is to be made and submitted for consideration. *See Pt 3, Ch 3, 4.1 General 4.1.2*.

8.7.6 Information required for engineering systems is listed in *Pt 4, Ch 1, 2 Information to be submitted*.

## Section 1
## Materials of construction

### 1.1 General

1.1.1 In general the Rules relate to the construction of linkspans in steel or aluminium alloys, although consideration will be given to the use of other materials.

1.1.2 The materials used in the construction of classed linkspans are to be manufactured and tested in accordance with the requirements of *Rules for the Manufacture, Testing and Certification of Materials, July 2020*. Materials for which provision is not made therein may be accepted, provided that they comply with an approved specification and such tests as may be considered necessary.

### 1.2 Steel

1.2.1 Steel having a specified minimum yield stress of 235 N/mm$^2$ (24 kgf/mm$^2$) is regarded as mild steel.

1.2.2 For the determination of pontoon scantlings where higher tensile steel is used, a higher tensile steel factor, *k*, given in *Table 2.1.1 Higher tensile steel factor, k*, is to be applied as indicated in the various prescriptive scantling formulae given in *Pt 3, Ch 4 Pontoons*.

**Table 2.1.1 Higher tensile steel factor, k**

| Specified minimum yield stress in N/mm$^2$ | $k$ |
|---|---|
| 315 | 0,78 |
| 340 | 0,74 |
| 355 | 0,72 |
| 390 | 0,68 |
| Note 1. Intermediate values by linear interpolation. | |
| Note 2. For mild steel $k$ = 1,0. | |

### 1.3 Aluminium

1.3.1 Except where otherwise stated, equivalent scantlings are to be derived as follows where aluminium alloys are used:

Plating thickness;

$$t_a = t_s c \sqrt{k_a}$$

Section modulus of stiffeners;

$$Z_a = Z_s k_a c$$

where

$c$ = 0,95 for high corrosion resistant alloy

= 1,00 for other alloys

where

$k_a = \dfrac{245}{\sigma_a}$

$t_a$ = equivalent thickness of aluminium plating

$t_s$ = thickness of mild steel plating

$Z_a$ = equivalent section modulus of aluminium stiffener

$Z_s$ = section modulus of mild steel stiffener

$\sigma_a$ = 0,2 per cent proof stress or 70 per cent of the ultimate strength of the material, whichever is the lesser ($N/mm^2$).

1.3.2 In general, for welded structures, the maximum value of $\sigma_a$ to be used in the derivation of scantlings is that of aluminium in the welded condition. However, consideration will be given to using unwelded values depending upon the weld line location, or other heat affected zones, in relation to the maximum applied stress on the member.

1.3.3 A comparison of the mechanical properties for selected welded and unwelded alloys is given in *Table 2.1.2 Minimum mechanical properties for selected aluminium alloys*.

**Table 2.1.2 Minimum mechanical properties for selected aluminium alloys**

| Alloy | Condition | | 0,2% proof stress $N/mm^2$ | | Ultimate tensile strength $N/mm^2$ | |
|---|---|---|---|---|---|---|
| | | | Unwelded | Welded (*see* Note 4) | Unwelded | Welded (*see* Note 4) |
| 5754 | O/H111 | | 80 | 80 | 190 | 190 |
| 5083 | O/H111 | | 125 | 125 | 275 | 275 |
| 5083 | H112 | | 125 | 125 | 275 | 275 |
| 5083 | H116/H321 | | 215 | 125 | 305 | 275 |
| 5086 | O/H111 | | 100 | 95 | 240 | 240 |
| 5086 | H112 | | 125 (*see* Note 2) | 95 | 250 (*see* Note 2) | 240 |
| 5086 | H116/H321 | | 195 | 95 | 275 | 240 |
| 6005A | T5/T6 | Extruded: Open Profile | 215 | 100 | 260 | 160 |
| (*see* Note 1) | | Extruded: Closed Profile | 215 | 100 | 250 | 160 |
| 6061 | T5/T6 | Rolled | 240 | 125 | 290 | 160 |
| (*see* Note 1) | | Extruded: Open Profile | 240 | 125 | 260 | 160 |
| | | Extruded: Closed Profile | 205 | 125 | 245 | 160 |
| 6082 | T5/T6 | Rolled | 240 | 125 | 280 | 190 |
| | | Extruded: Open Profile | 260 | 125 | 310 | 190 |
| | | Extruded: Closed Profile | 240 | 125 | 290 | 190 |

Note 1. These alloys are not normally acceptable for application in direct contact with sea-water.

Note 2. *See also Table 8.1.4 Minimum mechanical properties for acceptance purposes of selected extruded aluminium alloy products* in Chapter 8 of the Rules for Materials.

Note 3. The mechanical properties to be used to determine scantlings in other types and grades aluminium alloy manufactured to national or propriety standards and specifications are to be individually agreed with LR, *see also Ch 8, 1.1 Scope 1.1.5* of the Rules for Materials.

Note 4. Where detail structural analysis is carried out `Unwelded' stress values may be used away from heat affected zones and weld lines, *see also Pt 3, Ch 2, 1.3 Aluminium 1.3.2*.

1.3.4 Where strain hardened grades (designated Hxxx) are used, adequate protection by coating is to be provided to avoid the risk of stress corrosion cracking.

## ■ *Section 2* Fracture control

### 2.1 Grades of steel

2.1.1 The resistance to fracture is controlled, in part, by the notch toughness of the steel used in the structure. Steels with different levels of notch toughness are specified in *Rules for the Manufacture, Testing and Certification of Materials, July 2020*. The grade of steel to be used is, in general, related to the thickness of the material and the stress pattern associated with its location.

2.1.2 In general for locations where the Lowest Observed Daily Mean Ambient Temperature (LODMAT) is not less than 0°C the grade of steel used in the construction of the primary strength members of the facility is to comply with *Table 2.2.1 Steel grades*.

**Table 2.2.1 Steel grades**

| Thickness *t* (mm) | Mild Steel | H. T. Steel |
|---|---|---|
| t ≤ 20 | A | AH |
| 20 < t ≤ 25 | B | AH |
| 25 < t ≤ 40 | D | DH |
| t > 40 | E | EH |

2.1.3 Tee or cruciform welded connections should be avoided wherever possible. Where unavoidable, and the plate material is subject to significant strains in a direction perpendicular to the rolled surfaces, it is recommended that consideration be given to the use of special plate material with specified through thickness properties, as detailed in *Ch 3, 8 Plates with specified through thickness properties*.

2.1.4 For facilities with sub-zero design temperatures, the material for primary structural members is to comply with the requirements of *Table 2.2.2 Grades of steel for minimum design temperatures below 0 degrees C*.

**Table 2.2.2 Grades of steel for minimum design temperatures below 0 degrees C**

| Minimum design temperature, in °C | Thickness, in mm | Grades of steel |
|---|---|---|
| 0 to -10 | t ≤ 12,5 | B/AH |
| | 12,5 < t ≤ 25,5 | D/DH |
| | t > 25,5 | E/EH |
| -10 to -25 | t ≤ 12,5 | D/DH |
| | t > 12,5 | E/EH |

## ■ *Section 3* Corrosion protection

### 3.1 General

3.1.1 Where bimetallic connections are made, measures are to be incorporated to preclude galvanic corrosion.

### 3.2 Fabrication primers

3.2.1 Where a primer is used to coat steel after surface preparation and prior to fabrication, the composition of the coating is to be such that it will have no significant deleterious effect on subsequent welding work and that it is compatible with the paints or other coatings subsequently applied.

3.2.2 When unapproved primers are used tests are to be made as detailed in *Pt 3, Ch 2, 3.2 Fabrication primers 3.2.3*, *Pt 3, Ch 2, 3.2 Fabrication primers 3.2.4*, *Pt 3, Ch 2, 3.2 Fabrication primers 3.2.5* to determine the influence of the primer coating on the characteristics of welds.

3.2.3 Three butt weld assemblies are to be tested using plate material 20 to 25 mm thick. A `V' preparation is to be used and, prior to welding, the surfaces and edges are to be treated as follows:

(a) Assembly 1 - Uncoated
(b) Assembly 2 - Coated in accordance with manufacturer's instructions
(c) Assembly 3 - Coated to a thickness approximately twice the manufacturer's instructions.

3.2.4 Tests as follows are to be taken from each test assembly:

(a) **Radiographs.** These are to have a sensitivity of better than two per cent of the plate thickness under examination, as shown by an image quality indicator.
(b) **Photo-macrographs.** These may be of actual size and are taken from near each end and from the centre of the weld.
(c) **Face and reverse bend test.** The test specimens are to be bent by pressure or hammer blows round a former diameter equal to three times the plate thickness.
(d) **Impact tests.** These are to be carried out at ambient temperature on three Charpy V-notch test specimens prepared in accordance with *Ch 2, 3 Impact tests*. The specimens are to be notched at the centreline of the weld perpendicular to the plate surface.

3.2.5 The tests are to be carried out in the presence of an LR Surveyor or with the agreement of the Surveyor by an independent laboratory specializing in such work. A copy of the test report is to be submitted together with radiographs and macrographs.

### 3.3 Internal cathodic protection

3.3.1 Particular attention is to be given to the location of anodes, where fitted, in relation to the structural arrangements and openings of the tank.

3.3.2 Anodes are to be of approved design and sufficiently rigid to avoid resonance in the anode support. Steel cores are to be fitted, and these are to be designed to retain the anode even when the latter is wasted.

3.3.3 Anodes are to be attached to the structure in such a way that they remain secure both initially and during service. The following methods of attachment would be acceptable:

(a) Steel core connected to the structure by continuous welding of adequate section.
(b) Steel core bolted to separate supports, provided that a minimum of two bolts with lock nuts are used at each support. The separate supports are to be connected to the structure by continuous welding of adequate section.
(c) Approved means of mechanical clamping.

3.3.4 Anodes are to be attached to stiffeners, or may be aligned in way of stiffeners on plane bulkhead plating, but they are not to be attached to the shell. The two ends are not to be attached to separate members which are capable of relative movement.

3.3.5 Where cores or supports are welded to the main structure, they are to be kept clear of the toes of brackets and similar stress raisers. Where they are welded to asymmetrical stiffeners, they are to be connected to the web with the welding kept at least 25 mm away from the edge of the web. In the case of stiffeners or girders with symmetrical face plates, the connection may be made to the web or to the centreline of the face plate but well clear of the free edges. However, it is recommended that anodes are not fitted to face plates of higher tensile steel longitudinals.

### 3.4 Aluminium and magnesium anodes

3.4.1 Aluminium anodes are not to be located under tank hatches unless protected by adjacent structure.

3.4.2 Magnesium or magnesium alloy anodes are permitted only in tanks intended solely for water ballast.

### 3.5 External pontoon or steelwork protection

3.5.1 Suitable protection of the underwater portion of the pontoon and all submerged steelwork is to be provided.

3.5.2 Where an impressed current cathodic protection system is fitted, plans showing the proposed layout of anodes, reference cells and wiring diagrams are to be submitted.

3.5.3 The arrangement for glands, where cables pass through the shell, are to include a small cofferdam.

3.5.4 Where an ***IWS** (In-water Survey) notation is to be assigned (*see Pt 1, Ch 2, 3.4 Other notations 3.4.1*), protection of the underwater portion of the pontoon and/or other underwater steelwork is to be provided by means of a suitable high resistant paint applied in accordance with the manufacturer's requirements. Details of the high resistant paint are to be submitted for information.

### 3.6 Corrosion protection coatings for ballast spaces

3.6.1 At the time of new construction, all ballast spaces are to have an efficient protective coating, epoxy or equivalent, applied in accordance with the paint manufacturer's recommendations. The durability of the coatings could affect the frequency of survey of the spaces and light coloured coatings would assist in improving the effectiveness of subsequent surveys. It is therefore recommended that these aspects be taken into account by those agreeing the specification for the coatings and their application.

3.6.2 For further information and recommendations regarding the coating of ballast spaces see the *List of Paints, Resins, Reinforcements and Associated Materials* published by LR.

## Section 1
## General

### 1.1 Introduction

1.1.1 This Chapter indicates the general outline of the structural requirements which apply to the various elements which may be included in a linkspan namely, pontoons, bridges, ramps, walkways and supporting steelwork.

### 1.2 Pontoons

1.2.1 The structural requirements for the basic hulls of pontoons are highly prescriptive and are generally the same as those for pontoons covered by *Pt 3 Construction, Design and Test Requirements* and *Pt 4 Engineering Systems* of the *Rules and Regulations for the Classification of Ships* (hereinafter referred to as the Rules for Ships).

1.2.2 Pontoon designs complying with these basic hull requirements may be deemed to safely accommodate *inter alia*:

- hydrostatic loads on the hull resulting from heeling and trimming operations whilst the pontoon is freely floating up to the point of deck edge immersion, and
- any direct hydrodynamic loads on the hull which might occur at the geographic location for which class has been assigned,
- any additional loading from the effects of propeller or thruster wash from the berthing ship.

1.2.3 For greater pontoon immersions than deck edge immersion, *see Pt 3, Ch 4, 1.1 Application 1.1.6*.

1.2.4 Any further loads on the basic pontoon structure which arise as a result of vehicular traffic and/or of support given by the pontoon to associated bridges, vehicle ramps, and walkways or other applied loadings due to vehicle or pedestrian transfer are to be transmitted to the hull by suitable structural appendages fixed to the basic pontoon structure. These appendages are to comply with the load and design criteria given in *Pt 3, Ch 5 Bridge/Vehicle Ramp Strength* or *Pt 3, Ch 6 Passenger Walkway Strength*, as appropriate.

1.2.5 Structural reinforcement of the basic hull in way of these appendages is to be provided and suitably connected into the pontoon structure. The composite structure is also to comply with the load and design criteria given in Ch 5, *Pt 3, Ch 5, 3 Design loads and combinations* and *Pt 3, Ch 5, 4 Design criteria* as appropriate.

1.2.6 For pontoons with length to depth ratios exceeding six additional longitudinal strength calculations should be carried out.

### 1.3 Bridges and vehicle ramps

1.3.1 The structural requirements for bridges and vehicle ramps are less prescriptive than those for basic pontoon structures. They are determined from an allowable stress approach, using factored loads and other requirements given in *Pt 3, Ch 5 Bridge/Vehicle Ramp Strength*.

1.3.2 Specific details of the structural requirements for bridges and vehicle ramps are given in *Pt 3, Ch 5 Bridge/Vehicle Ramp Strength*.

### 1.4 Walkways

1.4.1 The structural requirements for walkways are less prescriptive than those for basic pontoon structures. They are determined from an allowable stress approach, using factored loads, and other requirements given in *Pt 3, Ch 6 Passenger Walkway Strength*.

1.4.2 Specific details for the structural requirements for walkways are given in *Pt 3, Ch 6 Passenger Walkway Strength*.

## ■ *Section 2* Structural idealization for pontoons

### 2.1 Geometric properties of section

2.1.1 The symbols used in this sub-Section are defined as follows:

$b$ = the actual width, in metres, of the load-bearing plating, i.e. one-half of the sum of spacings between parallel adjacent members or equivalent supports

$f$ = $0,3\left(\frac{l}{b}\right)^{\frac{2}{3}}$ , but is not to exceed 1,0. Values of this factor are given in *Table 3.2.1 Section geometry factor, f*

$l$ = the overall length of the primary support member, in metres, *see Figure 3.2.3 Span points*

$t_p$ = the thickness of the attached plating in mm. Where this varies, the mean thickness over the appropriate span is to be used

2.1.2 The effective geometric properties of rolled or built sections may be calculated directly from the dimensions of the section and associated effective area of attached plating. Where the web of the section is not normal to the attached plating, and the angle exceeds 20°, the properties of the section are to be determined about an axis parallel to the attached plating.

**Table 3.2.1 Section geometry factor, f**

| $\frac{l}{b}$ | $f$ | $\frac{l}{b}$ | $f$ |
|---|---|---|---|
| 0,5 | 0,19 | 3,5 | 0,69 |
| 1,0 | 0,30 | 4,0 | 0,76 |
| 1,5 | 0,39 | 4,5 | 0,82 |
| 2,0 | 0,48 | 5,0 | 0,88 |
| 2,5 | 0,55 | 5,5 | 0,94 |
| 3,0 | 0,62 | 6 and above | 1,00 |
| **Note** Intermediate values to be obtained by linear interpolation. | | | |

2.1.3 The geometric properties of rolled or built stiffener sections and of swedges are to be calculated in association with the effective area of attached load bearing plating of thickness $t_p$ and of width 600 mm or $40t_p$ whichever is the greater. In no case, however, is the width of plating to be taken as greater than either the spacing of the stiffeners or the width of the flat plating between swedges, whichever is appropriate. The thickness, $t_p$, is the actual thickness of the attached plating. Where this varies, the mean thickness over the appropriate span is to be used.

2.1.4 The effective section modulus of a corrugation over a spacing $p$ is to be calculated from the dimensions and, for symmetrical corrugations may be taken as:

$$Z = \frac{d_w}{6000}\left(3bt_p + ct_w\right) \text{ cm}^3$$

where $d_w$, $b$, $t_p$, $c$ and $t_w$ are measured in mm, and are as shown in *Figure 3.2.1 Corrugated section* The value of $b$ is to be taken not greater than:

= $50t_p\sqrt{k}$ for welded corrugations

= $60t_p\sqrt{k}$ for cold formed corrugations

= The value of θ is to be not less than 40°.

The moment of inertia is to be calculated from:

$$I = \frac{Z}{10}\left(\frac{d_w}{2}\right) \text{ cm}^4$$

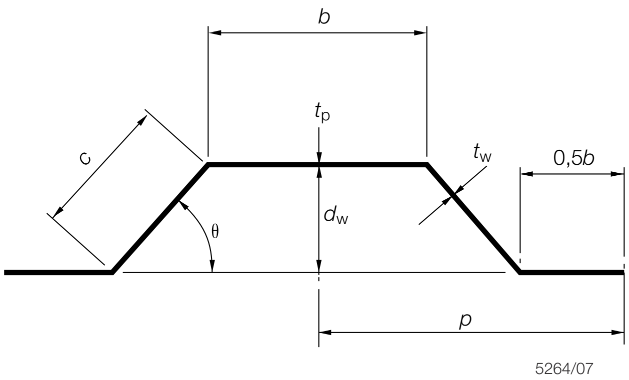



**Figure 3.2.1 Corrugated section**

2.1.5 The section modulus of a double plate bulkhead over a spacing $b$ may be calculated as:

$$Z = \frac{d_w}{6000}\left(6fbt_p + d_w t_w\right) \text{ cm}^3$$

where $d_w$, $b$, $t_p$ and $t_w$ are measured, in mm, and are as shown in *Figure 3.2.2 Double plate bulkhead section*

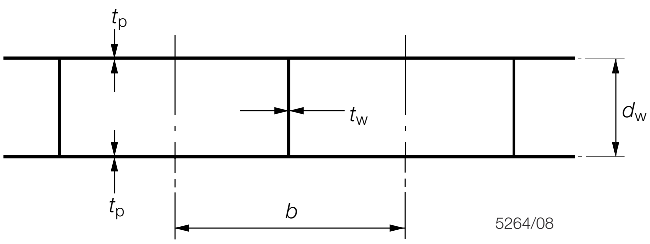



**Figure 3.2.2 Double plate bulkhead section**

2.1.6 The effective section modulus of a built section may be taken as:

$$Z = \frac{ad_w}{10} + \frac{t_w d_w^2}{6000}\left(1 + \frac{200(A - a)}{200A + t_w d_w}\right) \text{ cm}^3$$

where

$a$ = the area of the face plate of the member, in $cm^2$

$d_w$ = the depth, in mm, of the web between the inside of the face plate and the attached plating. Where the member is at right angles to a line of corrugations, the minimum depth is to be taken

$t_w$ = the thickness of the web of the section, in mm

$A$ = the area of the attached plating in $cm^2$, *see Pt 3, Ch 3, 2.1 Geometric properties of section 2.1.7*. If the calculated value of $A$ is less than the face area $a$, then $A$ is to be taken as equal to $a$.

2.1.7 The geometric properties of primary support members (i.e. girders, transverses, webs, stringers, etc.) are to be calculated in association with an effective area of attached load bearing plating, $A$, determined as follows:

(a) For a member attached to plane plating:

$$A = 10fbt_p \text{ cm}^2$$

where $b$ is as defined in *Pt 3, Ch 3, 2.1 Geometric properties of section 2.1.1*.

(b) For a member attached to corrugated plating and parallel to the corrugations (where $b$ is as defined in *Pt 3, Ch 3, 2.1 Geometric properties of section 2.1.4*, *see also Figure 3.2.1 Corrugated section*):

$$A = 0{,}01bt_p \text{ cm}^2$$

(c) For a member attached to corrugated plating and at right angles to the corrugations:

$A$ is to be taken as equivalent to the area of the face plate of the member.

### 2.2 Determination of span point

2.2.1 The effective length, $l_e$, of a stiffening member is generally less than the overall length, $l$, by an amount which depends on the design of the end connections. The span points, between which the value of $l_e$ is measured, are to be determined as follows:

(a) For rolled or built secondary stiffening members:

The span point is to be taken at the point where the depth of the end bracket, measured from the face of the secondary stiffening member is equal to the depth of the member. Where there is no end bracket the span point is to be measured between primary member webs. For double skin construction the span may be reduced by the depth of the primary member web stiffener, *see Figure 3.2.3 Span points*

(b) For primary support members:

The span point is to be taken at a point distant $b_e$ from the end of the member (*see Figure 3.2.3 Span points*), where:

$$b_e = b_b\left(1 - \frac{d_w}{d_b}\right)$$

2.2.2 Where the stiffener member is inclined to a vertical or horizontal axis and the inclination exceeds 10°, the span is to be measured along the member.

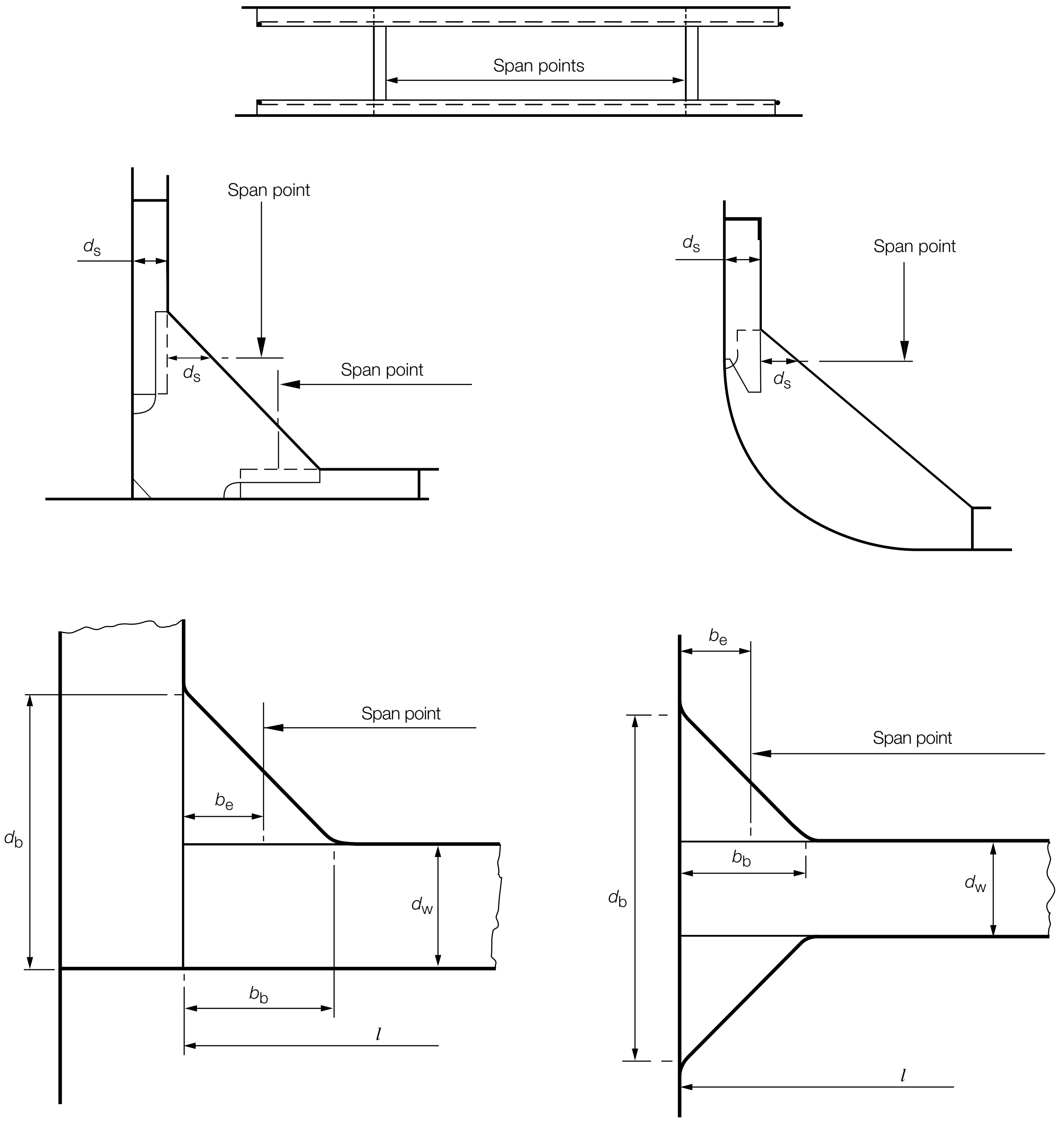



**Figure 3.2.3 Span points**

2.2.3 It is assumed that the ends of stiffening members are substantially fixed against rotation and displacement. If the arrangement of supporting structure is such that this condition is not achieved, consideration will be given to the effective span to be used for the stiffener.

## Section 3
## Design loading

### 3.1 General

3.1.1 This Section describes the various types of loadings to be applied to Linkspans when assessing their structural adequacy at the intended service location.

### 3.2 Hydrostatic loads

3.2.1 The scantlings of pontoons, buoyancy tanks and buoyancy spaces in linkspan bridge sections are to be assessed on the basis of a static pressure load equivalent to the geometric depth, $D$ of the pontoon or buoyancy tank.

3.2.2 Submerged buoyancy tank scantlings are to be based on the maximum depth of water above the base of the tank.

### 3.3 Dead loads

3.3.1 The self weight, including weight of steel, welding, any surfacing or cladding material, or machinery items is to be taken into account in the calculations of bridges, ramps, walkways, support structures, bearings, connections or joints, as appropriate.

### 3.4 Vehicle loads

3.4.1 Individual tyre prints (load and patch area) are to be considered when establishing the deck plate thickness of pontoons, ramps and bridges.

3.4.2 Axle loads and spacings are to be considered for the adequacy of deck strength members.

3.4.3 To allow for the possibility of emergency braking or skidding incidents, a horizontal load of 0,2 × vehicle weight is to be considered in conjunction with the vertical vehicle loadings.

3.4.4 A design uniformly distributed load (UDL) may be considered for establishing the overall, global strength of vehicle carrying decks, ramps or bridges. Such a UDL is to be used for defining the rated load, or SWL, where appropriate, of any deck, ramp or bridge structure and for determining the appropriate proof test load.

3.4.5 Alternatively, vehicle carrying decks, ramps or bridges may be assessed on the basis of HA and HB loading, or other equivalent National or International loading Standards. Definitions of HA and HB loading are given in *Pt 3, Ch 9 Highway Loads, Section Aerodynamics and Pontoon Drag Coefficients*.

3.4.6 When requested the loadings from trains and railway wagons will be specially considered.

### 3.5 Walkway loading

3.5.1 Walkways are generally assessed on the basis of a pedestrian UDL of 5 kN/m$^2$ acting over the internal floor area, unless otherwise stated by the designer.

### 3.6 Wind loading

3.6.1 Each linkspan, and its mooring or tethering arrangements, is to be capable of withstanding:

(a) the specified maximum wind speed in which the linkspan will continue in normal service, and
(b) an extreme, out of normal service, wind speed - based on a 1 in 50 years return period.

3.6.2 The design wind speeds are to be based on local climatological data.

Where the wind speeds are not defined by reliable local meteorological records, the following values may be used:

(a) 20 m/s for the normal in-service condition
(b) 63 m/s for the out-of-service condition.

3.6.3 The wind force, $F_{\text{w}}$ acting on the linkspan structure is to be calculated from the expression:

$$F_{\text{w}} = APC_{\text{f}}$$

where

$A$ = the effective area of the structure i.e. the solid area projected on a plane perpendicular to the wind direction, in m$^2$

$P$ = wind pressure in N/m$^2$

where

$P = 0{,}613\, v^2$

where

$v$ = wind speed, in m/s

$C_f$ = force coefficient in the direction of the wind.

3.6.4 The value of $C_f$ will depend on other factors including:

- aerodynamic slenderness
- section ratios
- shielding factors
- solidity factor

Definitions of these various factors are given in *Pt 3, Ch 9 Highway Loads, Section Aerodynamics and Pontoon Drag Coefficients*.

### 3.7 Current loading

3.7.1 Each linkspan is to be capable of withstanding the maximum prevailing current speed without loss of effective station-keeping capability.

3.7.2 The maximum current speed is to be based on the most unfavourable combinations of tide, surge and wind induced currents for a return period of 1 in 50 years, or other equivalent available data.

3.7.3 The current force, $F_c$ acting on the linkspan is to be calculated from the expression.

$$F_c = 0{,}5 C_D \rho v^2 A \text{ kN}$$

where

$C_D$ = drag coefficient in direction of current

$\rho$ = density of water, in t/m$^3$

$v$ = incident current velocity impinging on the pontoon, in m/s

$A$ = submerged area of pontoon normal to the current flow direction, in m$^2$.

3.7.4 The calculation of the drag coefficient, $C_D$, can be complex and will depend on the shape of the pontoon, extent of marine growth, depth of water under the pontoon and breadth/depth ratio of pontoon. A value of $C_D$ may be calculated in accordance with the method in *Pt 3, Ch 9 Highway Loads, Section Aerodynamics and Pontoon Drag Coefficients*.

### 3.8 Wave loading

3.8.1 In general, linkspans are to be located in sheltered positions where the effects of wave impingement will not be severe. The forces due to any wave action are to be considered in the design of the mooring or tethering system.

3.8.2 Where it can be assumed that waves impinging on pontoons will be reflected, forces should be calculated as for a standing wave with the pontoon assumed to be located at a node point.

3.8.3 The maximum pressure, $P_y$ on the pontoon elevation, $y$, relative to the still water level may be taken as:

$$P_y = \rho g y + \rho g H_{inc} \cosh\,[2\pi(y + d)/L]/\cosh\,(2\pi d/L) \text{ kN/m}^2$$

where

$\rho$ = mass density of water, in t/m$^3$

where

$g$ = acceleration due to gravity, in m/s$^2$

$y$ = elevation on pontoon relative to still water level measured positively upwards, in metres

$H_{inc}$ = incident wave height, in metres

$d$ = still water depth, in metres

$L$ = wavelength (crest-to-crest), in metres.

3.8.4 For locations where wave drift occurs the mean wave drift force, $F_{wd}$ for an irregular sea may be calculated using the following equation:

$$F_{wd} = \frac{\rho \, g L H^2_s}{16} \text{ kN}$$

where

$H_s$ = significant wave height, in metres.

3.8.5 For linkspans being specially considered under *Pt 1, Ch 2, 1.2 Application 1.2.3* a more rigorous treatment of the effects of wave action is required. Reference should be made to BS 6349: Parts 1 and 6, or any other relevant National Standard.

### 3.9 Ship induced loadings

3.9.1 Where appropriate, linkspans are to be designed to accommodate any horizontal and vertical forces from the end berthing manoeuvres of ships for:

(a) normal, operational berthing contact;
(b) abnormal, or heavy berthing contact.

3.9.2 The berthing energy, $E$ of the ship is to be calculated from the equation:

$$E = 0{,}5m \, (V \cos \alpha)^2 \text{ kNm}$$

where

$m$ = ship's maximum displacement, in tonnes

$V$ = ship's contact speed, in m/s

$\alpha$ = approach angle of ship.

3.9.3 The reaction force, $R$ imparted into the linkspan's structure by the fender's absorption of the berthing energy is to be obtained from the manufacturer's published performance curves for the particular fender installed. It is recommended that $R$ is increased by 10 per cent, or otherwise as suggested by the manufacturer, to allow for possible variations in the nominal values obtained from the performance curves.

3.9.4 To allow for heavy berthing incidents caused by possible accidental occurrences, the ultimate energy absorption capacity of fenders is to be twice that for normal conditions. Any heavy berthing incident resulting in damage, defect or breakdown which could adversely affect the ability of the linkspan to accommodate the conditions for which a Class has been assigned is to be reported to LR without delay, *see Pt 1, Ch 2, 1.1 General 1.1.7*.

3.9.5 Where appropriate (*see Pt 1, Ch 2, 1.2 Application 1.2.2*), linkspans are also to be considered for the effects of the following other ship induced loadings:

(a) Mooring forces transmitted to the linkspan, *see Pt 1, Ch 2, 1.2 Application 1.2.2*.
(b) For linkspans that derive support from the berthed ship, any forces applied through the connecting strops or links caused by motion of the ship.
(c) The forces of water jets or other propulsion units that may impinge on submerged parts of the linkspan.
(d) The effects of wash from passing marine craft.
(e) The effects of vehicles braking or trains striking the buffers when on board the berthed ship.

### 3.10 Towage loading

3.10.1 Where it is intended to tow the linkspan from its construction site to port of operation, it will be necessary to assess the pontoon structure for the appropriate loadings associated with the tow voyage, in addition to the hydrostatic load and other loads defined previously.

### 3.11 Snow and ice loading

3.11.1 Where appropriate, and unless otherwise stated by the designer, snow and ice loading of 2 kN/$m^2$ is to be applied to surfaces within 12 per cent of the horizontal.

## ■ *Section 4* **Fatigue assessment**

### 4.1 General

4.1.1 The design life of the linkspan is to be specified.

4.1.2 For all critical components subject to significant cyclical loading a fatigue assessment in accordance with a recognized National or International Standard is to be made and submitted for consideration. This will apply especially to all articulated connections, support points and traffic lane structures, particularly to those spanning between a pontoon and the shore where the effects of continuous pontoon movement and sliding friction bearings may be significant.

4.1.3 Consideration should also be given to details subject to small amplitude motions of the pontoon or other buoyant support causing a high number of cycles at low stress levels.

## ■ *Section 5* **Model tests**

### 5.1 General

5.1.1 Linkspans, which in the opinion of LR, are likely to be exposed to incalculable environmental conditions including combinations of swell/wave should, in the absence of other evidence, have model tests carried out to establish the likely behavioural response of the linkspan to these effects.

5.1.2 Model tests are to be carried out where the effects of passing ships or the effects of the berthing ship's propulsion units are, in the opinion of the Designer, likely to be significant.

5.1.3 Testing is to be carried out by a recognized specialist acceptable to LR and the tests are to represent accurately the conditions prevailing at the location of the linkspan.

5.1.4 Model tests may be either physical or mathematical as agreed with LR.

5.1.5 Results of any model tests are to be submitted.

## ■ *Section 1* General

### 1.1 Application

1.1.1 This Chapter applies to pontoons used for providing buoyant support for ship-to-shore ramps forming part of a linkspan and which are intended for operation in protected waters (*see Pt 1, Ch 2, 1.2 Application 1.2.5*).

1.1.2 For pontoons intended for operation in inland waterways, longitudinal strength calculations are to be carried out in accordance with the relevant requirements of the *Rules and Regulations for the Classification of Inland Waterways Ships, July 2020*.

1.1.3 Where required, pontoons are to be fitted with adequate arrangements for towing. In general, such arrangements are to consist of, or be equivalent to, not less than two sets of bollards, each set being suitable for accepting a towline of suitable breaking strength, *see also Pt 3, Ch 10 Towing and Lifting Arrangements*.

1.1.4 Where it is intended to lift a pontoon, the relevant requirements of *Pt 3, Ch 10 Towing and Lifting Arrangements* are to be complied with.

1.1.5 For pontoons with an L > 6*D* (*see Pt 3, Ch 4, 1.3 Symbols and definitions 1.3.1*), longitudinal strength calculations are to be carried out in accordance with the *Rules and Regulations for the Classification of Ships, July 2020*, *Pt 3, Ch 4 Pontoons* where the ship service factor, $f_1$, is to be taken as 0,5.

1.1.6 Pontoons that are submerged to act as buoyancy chambers will be specially considered taking into account the increase in hydrostatic pressure. Stability must also be considered for this type of buoyant arrangement.

1.1.7 Pontoons which are designed to take the ground will be specially considered.

### 1.2 Information required for approval

1.2.1 Reference is to be made to *Pt 3, Ch 1, 8 Information required for approval* regarding information to be submitted for approval.

### 1.3 Symbols and definitions

1.3.1 The Rule length, *L*, is to be taken as the overall length for square ended pontoons, or for pontoons with swim ends *L* need not exceed 97 per cent of the extreme length at the waterline at maximum working draught condition, $L_1$, *see Figure 4.1.1 Pontoon dimensions*.

1.3.2 Breadth, *B*, is the greatest moulded breadth, in metres.

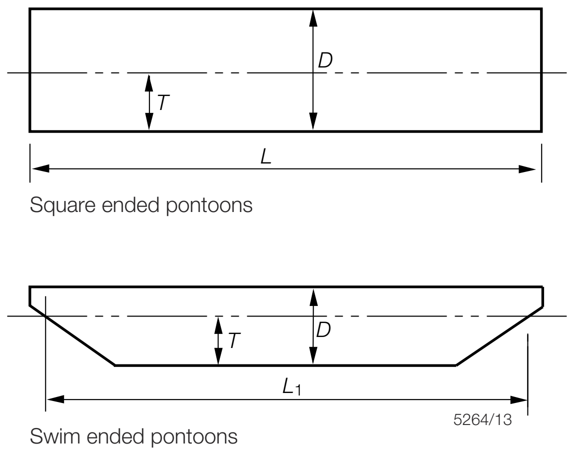



**Figure 4.1.1 Pontoon dimensions**

1.3.3 Depth, $D$, is measured, in metres, at the middle of the length, $L$, from top of bottom plating to top of the deck plating at side on the uppermost continuous deck.

1.3.4 Draught, $T$, is the maximum working draught, in metres, measured from top of bottom plating.

1.3.5 Head, $h$, in metres, is to be taken as:

(a) for bottom longitudinals, frames, girders and transverses: the depth $D$

(b) for side longitudinals:

the distance of the longitudinal below the deck at side, but not less than $0{,}01L + 0{,}7$

(c) for side frames and transverses:

the distance from the mid-point of span to the deck at side, but not less than $0{,}01L + 0{,}7$

(d) for weather deck longitudinals and transverses: a head of $0{,}01L + 0{,}7$.

### 1.4 Longitudinal or transverse framing

1.4.1 Pontoons used for this application may be longitudinally or transversely framed.

## ■ *Section 2* Longitudinal strength

### 2.1 Design loads

2.1.1 The longitudinal strength of pontoons with $L/D > 6$ is to be considered for the worst combination of imposed loadings. (*See Pt 3, Ch 3, 3 Design loading*).

### 2.2 Calculation of pontoon section modulus

2.2.1 Section modulus calculations are required on all pontoons with an $L/D > 6$.

2.2.2 All continuous longitudinal structural components are to be included in the calculation of the inertia of the pontoon midship section, where appropriate, and the lever $z$ is to be measured vertically from the neutral axis to the top of bottom plating and to the moulded strength deck line at the side. Where the deck is stepped the hull section modulus for sections between the deck overlaps may be calculated using a mean height $h_{mean}$, as indicated in *Figure 4.2.1 Stepped decks*. If the deck thickness varies between the stepped decks, the lesser value is to be used in the calculation of section modulus.

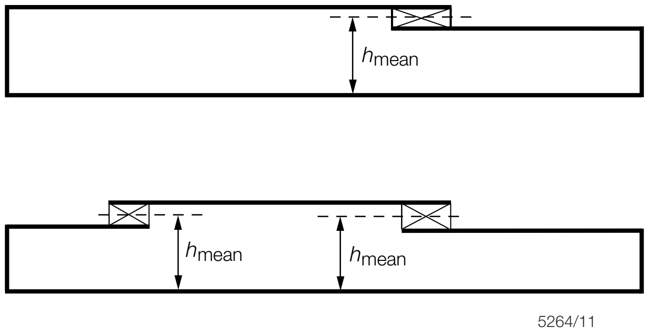



**Figure 4.2.1 Stepped decks**

2.2.3 Deck openings having a length in the fore and aft directions exceeding 2,5 m or a breadth exceeding 1,2 m or 0,04*B* m, whichever is the lesser, are always to be deducted from the sectional areas used in the section modulus calculation.

2.2.4 Deck openings smaller than those referred to in *Pt 3, Ch 4, 2.2 Calculation of pontoon section modulus 2.2.3* including manholes, need not be deducted provided they are isolated and the sum of their breadths or shadow area breadths, *see Pt 3, Ch 4, 2.2 Calculation of pontoon section modulus 2.2.5*, in one transverse section does not exceed $0,06(B_1 - \Sigma b_1)$

where

$B_1$ = breadth of pontoon at section considered

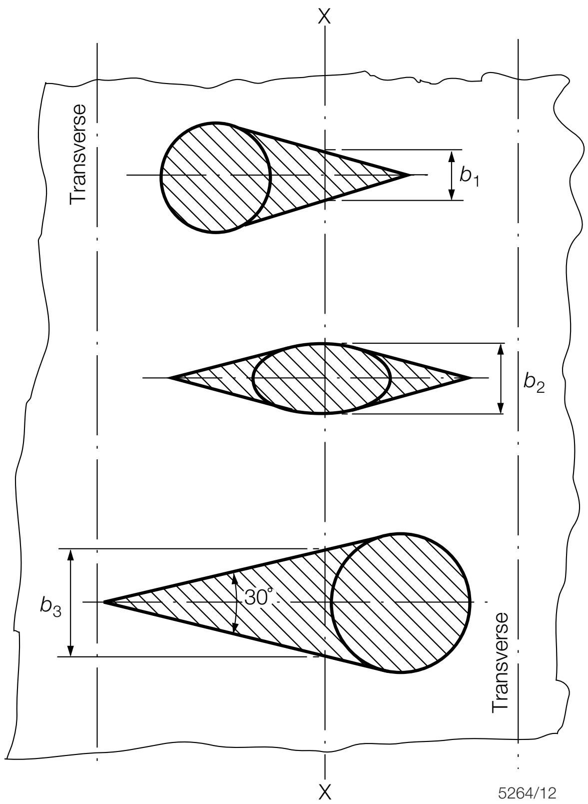
$\Sigma b_1$ = sum of breadths of deductible openings

Where a large number of deck openings are proposed in any transverse space, special consideration will be required.

2.2.5 In the calculation of deduction-free openings, the openings are assumed to have longitudinal extensions as shown by the shaded areas in *Figure 4.2.2 Deduction-free openings*. The shadow area is obtained by drawing two tangent lines to an opening angle of 30°. The section to be considered should be perpendicular to the centreline of the pontoon and should result in the maximum deduction in each transverse space.

2.2.6 Isolated openings in longitudinals or longitudinal girders need not be deducted if their depth does not exceed 25 per cent of the web depth with a maximum depth for scallops of 75 mm.

2.2.7 Openings are considered isolated if they are spaced more than 1 m apart in either the transverse or longitudinal direction.




Total equivalent breadth of small openings
at xx = $b_1 + b_2 + b_3$

**Figure 4.2.2 Deduction-free openings**

2.2.8 Deck openings should be avoided in areas of high stress.

### 2.3 Permissible hull vertical bending and shear stresses

2.3.1 The permissible stress for hull vertical bending, σ, is given by:

$$\sigma = \frac{175}{k} \text{ N/mm}^2$$

2.3.2 The permissible shear stress, τ, is given by:

$$\tau = \frac{110}{k} \text{ N/mm}^2$$

where

$k$ = material factor, *see Pt 3, Ch 2, 1.2 Steel*.

## ■ *Section 3* Hull envelope plating

### 3.1 Bottom shell plating

3.1.1 The bottom shell plating thickness is to comply with the requirements of *Table 4.3.1 Bottom shell and bilge plating*.

**Table 4.3.1 Bottom shell and bilge plating**

| Location | Longitudinal framing | Transverse framing |
|---|---|---|
| (1) Bottom plating | The greater of the following:<br>(a) $t = \dfrac{0,001 s_1 (0,043L + 10)}{\sqrt{k}}$<br>(b) $t = 0,00582 s_1 \sqrt{h_{T2} k}$ | The greater of the following:<br>(a) $t = \dfrac{0,001 s_1 f_1 (0,056L + 16,7)}{\sqrt{k}}$<br>(b) $t = 0,00705 s_1 \sqrt{h_{T2} k}$ |

*L*, *D*, *T* as defined in *Pt 3, Ch 4, 1.3 Symbols and definitions*

$s$ = spacing of frames, beams or longitudinals, in mm

$S$ = spacing or mean spacing of girders, transverses or floors, in metres

$k$ = material factor, *see Pt 3, Ch 2, 1.2 Steel*

$C_W$ = wave head, in metres

= $7,71 \times 10^{-2} L.e^{-0,0044L}$

= where e is the base of natural logarithms 2,71828

$f_1$ = $\dfrac{1}{1 + \left(\dfrac{s}{1000S}\right)^2}$

$h_{T2}$ = ($T$+0,5$C_W$), in metres but need not be taken greater than 1,2$T$ m

$s_1$ = $s$, but is not to be taken less than the smaller of $470 + \dfrac{L}{0,6}$ mm or 700 mm

### 3.2 Side and end shell plating

3.2.1 The side and end shell plating thickness is to comply with the requirements of *Table 4.3.2 Side and end shell plating*.

3.2.2 Sea inlets, or other openings, are to have well rounded corners and so far as possible, are to be kept clear of the bilge radius, if any. Openings on, or near to, the bilge radius are to be elliptical. The thickness of sea inlet box plating is to be the same as the adjacent shell, but not less than 12,5 mm and need not exceed 25 mm.

### 3.3 Deck plating

3.3.1 The pontoon deck plating thickness ($t$) is to comply with the requirements for strength/weather deck plating given in *Table 4.3.3 Strength/weather deck plating*.

3.3.2 Additionally, where the pontoon deck will be subject to vehicular loading, the plating is to be designed for the maximum tyre print and axle loads that will use the linkspan.

3.3.3 Details of the vehicle types using the deck are to be submitted. These are to include:

- Wheel loads.
- Axle and wheel spacings.
- Tyre print dimensions.
- Type of tyre fitted (solid or pneumatic).

3.3.4 The deck plating thickness, $t$, is to be not less than:

$$t = t_1 + t_c \text{ mm}$$

where

$t_c$ = wear and wastage allowance = 1,5 mm

$t_1$ = $\dfrac{\alpha s}{1000\sqrt{k}}$ mm

where

$P_1$ = corrected patch load obtained from *Table 4.3.4 Corrected patch loading*

$k$ = material factor, *see Pt 3, Ch 2, 1.2 Steel*

$\alpha$ = thickness coefficient obtained from *Figure 4.3.1 Tyre print chart*

$\beta$ = tyre print coefficient used in *Figure 4.3.1 Tyre print chart*

$$= \log_{10}\left(\frac{P_1 k^2}{s^2} \times 10^7\right)$$

$s$ = spacing, in mm of frames, beams or longitudinals, as appropriate.

3.3.5 Where a transversely framed deck contributes to the hull girder strength or where secondary stiffening is fitted perpendicular to the direction of vehicle lanes, the thickness, $t$, derived from *Pt 3, Ch 4, 3.3 Deck plating 3.3.4* is to be increased by 1,0 mm.

3.3.6 Where it is proposed to carry tracked vehicles, the patch dimensions may be taken as the track print dimensions and $P_w$ is to be taken as half the total weight of the vehicle. The wear and wastage allowance, $t_c$, is to be increased by 0,5 mm.

3.3.7 Deck fittings in way of vehicle lanes are to be recessed.

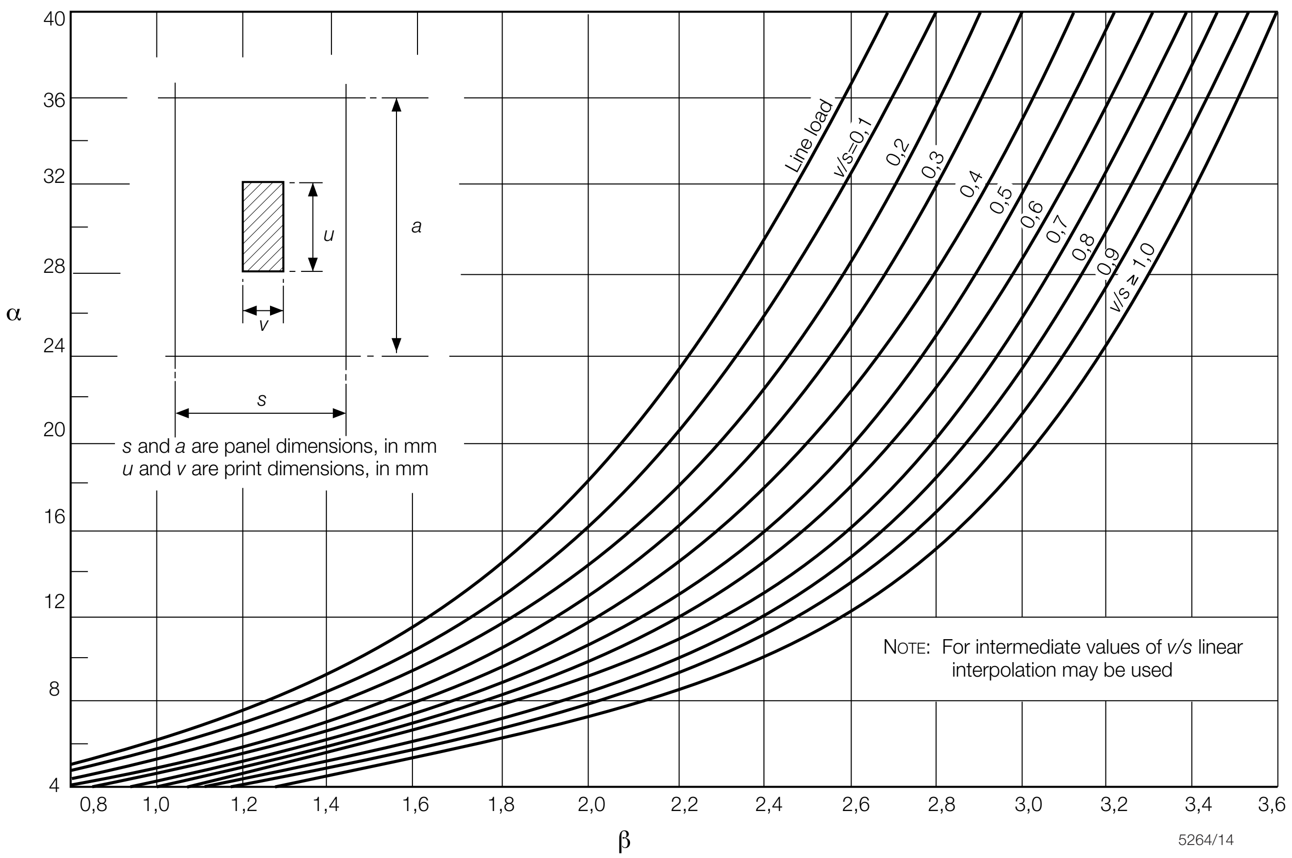



**Figure 4.3.1 Tyre print chart**

**Table 4.3.2 Side and end shell plating**

| Location | Thickness, in mm | |
|---|---|---|
| | Longitudinal framing | Transverse framing |
| (1) Side shell clear of sheerstrake | (a) Above $\frac{D}{2}$ from the base:<br>The greater of the following:<br>(i) $t = \frac{0,001 s_1 (0,059L + 7)}{\sqrt{k}}$<br>(ii) $t = 0,0042 s_1 \sqrt{h_{T1} k}$ | (a) Within $\frac{D}{4}$ from the gunwale:<br>The greater of the following:<br>(i) $t = \frac{0,00085 s_1 f_1 \left(0,083 L_1 + 10\right)}{\sqrt{k}}$<br>(ii) $t = 0,0042 s_1 \sqrt{h_{T1} k}$ |
| | (b) Up to $\frac{D}{2}$ from the base:<br>The greater of the following:<br>(i) $t = \frac{0,001 s_1 \left(0,059 L_1 + 7\right)}{\sqrt{k}}$<br>(ii) $t = 0,0054 s_1 \sqrt{h_{T2} k}$ | (b) Up to $\frac{D}{4}$ from mid-depth:<br>The greater of the following:<br>(i) $t = \frac{0,001 s_1 \left(0,059 L_1 + 7\right)}{\sqrt{k}}$<br>(ii) $t = 0,0051 s_1 \sqrt{h_{T1} k}$ |
| | | (c) Within $\frac{D}{4}$ from base:<br>(i) $t = \frac{0,00085 s_1 f_1 \left(0,083 L_1 + 10\right)}{\sqrt{k}}$<br>(ii) $t = 0,00626 s_1 \sqrt{h_{T2} k}$ |

*L*, *D* as defined in *Pt 3, Ch 4, 1.3 Symbols and definitions*

$L_1$ = as defined in *Figure 4.1.1 Pontoon dimensions*

$k$ = material factor *see Pt 3, Ch 2, 1.2 Steel*

$C_w$ = wave head, in metres

= $7,71 \times 10^{-2} L.e^{-0,0044L}$

= where e is the base of natural logarithms 2,71828

$f_1$ = $\frac{1}{1 + \left(\frac{s}{1000S}\right)^2}$

$h_{T1}$ = $T + C_w$, in metres but need not be taken greater than $1,36T$ m

$h_{T2}$ = $(T + 0,5C_w)$, in metres but need not be taken greater than $1,2T$ m

$s_1$ = $s$, but is not to be taken less than the smaller of $470 + \frac{L}{0,6}$ mm or 700 mm

$s$ = spacing of frames, beams or longitudinals, in mm

**Table 4.3.3 Strength/weather deck plating**

| Location | Minimum thickness, in mm | |
|---|---|---|
| | Longitudinal framing | Transverse framing |
| (1) Deck plating | The greater of the following:<br>(a) $t = \dfrac{0,001 s_1 (0,059L + 7)}{\sqrt{k}}$<br>(b) $0,00083 s_1 \sqrt{Lk} + 2,5$ | The greater of the following:<br>(a) $t = \dfrac{0,001 s_1 f_1 (0,083L + 10)}{\sqrt{k}}$<br>(b) $0,001 s_1 \sqrt{Lk} + 2,5$ |
| (2) In way of the crown of a tank | $t = 0,004 s f \sqrt{\dfrac{\rho\ k h_4}{1,025}} + 3,5$<br>or as (1) whichever is the greater, but not less than 6,5 mm | |

*L* as defined in *Pt 3, Ch 4, 1.3 Symbols and definitions*

$\rho$ = relative density (specific gravity) of liquid carried in a tank, but is not to be taken less than 1,025

$k$ = material factor *see Pt 3, Ch 2, 1.2 Steel*

$s$ = spacing of frames, beams or longitudinals, in mm

$S$ = spacing or mean spacing or girders, transverses or floors, in metres

$f$ = $1,1 - \dfrac{s}{2500\,S}$ but not to be taken greater than 1,0

$f_1$ = $\dfrac{1}{1 + \left(\dfrac{s}{1000S}\right)^2}$

$h_4$ = tank head, in metres, *see Table 4.5.1 Watertight and ballast tank bulkhead scantlings*

$s_1$ = $s$, but is not to be taken less than the smaller of $470 + \dfrac{L}{0,6}$ mm or 700 mm

**Table 4.3.4 Corrected patch loading**

| Expression | |
|---|---|
| $P_1 = \varphi_1 \varphi_2 \varphi_3 \lambda P_w$ | |
| $\varphi_1 = \frac{2v+1,1s}{u_1+1,1s}$ | $v_1 = v$, but not > $s$<br>$u_1 = u$, but not > $a$ |
| $\varphi_2 = 1,0$ | for $u \le (a - s)$ |
| $= \frac{1}{1,3 - \frac{0,3}{s}(a-u)}$ | for $a \ge u > (a - s)$ |
| $= 0,77\frac{a}{u}$ | for $u > a$ |
| $\varphi_3 = 1,0$ | for $v < s$ |
| $= 0,6\frac{s}{v} + 0,4$ | for $1,5 > \frac{v}{s} \ge 1,0$ |
| $= 1,2\frac{s}{v}$ | for $\frac{v}{s} \ge 1,5$ |
| $\lambda = ,125$ | |

*a*, *s*, *u*, and *v* as defined in *Figure 4.3.1 Tyre print chart*

$n$ = tyre correction factor, *see Table 4.3.5 Tyre correction factor, n*

$P_w$ = load, in tonnes, on the tyre print. For closely spaced wheels the shaded area shown in *Figure 4.3.1 Tyre print chart* may be taken as the combined print.

$P_1$ = corrected patch load, in tonnes

$\lambda$ = dynamic magnification factor

$\varphi_1$ = patch aspect ratio correction factor

$\varphi_2$ = patch aspect ratio correction factor

$\varphi_3$ = wide patch load factor

**Table 4.3.5 Tyre correction factor, n**

| Number of wheels in idealized patch | Pneumatic tyres | Solid rubber tyres | Steel or solid tyres |
|---|---|---|---|
| 1 | 0,6 | 0,8 | 1,0 |
| 2 or more | 0,75 | 0,9 | 1,0 |

## Section 4
## Hull envelope framing

### 4.1 General

4.1.1 Bottom, side and deck transverses are to be connected in such a manner as to ensure continuity of the transverse ring system, and longitudinals are to be attached to transverses. In way of deck and bottom transverses, a deep web frame may be required to be fitted.

4.1.2 End connections of longitudinals at bulkheads are to provide adequate fixity and continuity of longitudinal strength.

4.1.3 Brackets at the top and bottom of side frames are to extend to the deck and bottom longitudinals to which they are to be attached.

4.1.4 In pontoons where truss arrangements, comprising top and bottom girders in association with pillars and diagonal bracing, are used in the support of the deck loads, the diagonal members are generally to have angles of inclination with the horizontal of about 45° and cross-sectional area of at least 50 per cent of the adjacent pillar in accordance with *Pt 3, Ch 4, 6 Pillars*.

4.1.5 Adequate support is to be provided for the loads imposed on the structure when the pontoon is in dry-dock.

### 4.2 Longitudinal framing

4.2.1 The scantlings of bottom, side and deck longitudinals are to comply with the requirements of *Table 4.4.1 Longitudinal framing*.

**Table 4.4.1 Longitudinal framing**

| Position of longitudinals | Modulus, in cm$^3$ |
|---|---|
| Bottom | $Z = 11{,}0\, k\, l_e^{\,2}\, s\, h \times 10^{-3}$ |
| Side and end shell | $Z = 8{,}0\, k\, l_e^{\,2}\, s\, h \times 10^{-3}$ |
| Deck | $Z = 5{,}5\, k\, l_e^{\,2}\, s\, h \times 10^{-3}$ |
| *h* as defined in *Pt 3, Ch 4, 1.3 Symbols and definitions 1.3.5*<br>$Z$ = section modules of stiffening member, in cm$^3$, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*<br>$l_e$ = effective length of stiffening member, in metres, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*<br>$s$ = spacing of frames, beams, or longitudinals, in mm<br>$k$ = material factor *see Pt 3, Ch 2, 1.2 Steel* | |

4.2.2 In addition, the following requirements for depth to thickness ratios of longitudinals are to be met:

(a) Flat bar longitudinal:

(i) when continuous at bulkheads

$$\frac{d_w}{t_w} \leq 18\sqrt{k}$$

(ii) when non-continuous at bulkheads

$$\frac{d_w}{t_w} \leq 15\sqrt{k}$$

(b) Built sections

(i) $\dfrac{d_w}{t_w} \leq 60\sqrt{k}$

(ii) $\dfrac{b_f}{t_f} \leq 15\ for$ asymmetric sections

(iii) $\dfrac{bf}{t_f} \leq 30\ for$ symmetric sections

where

$k$ = material factor, *see Pt 3, Ch 2, 1.2 Steel*

$d_w$ = depth of web, in mm

$t_w$ = thickness of web, in mm

$b_f$ = width of face plate, in mm

$t_f$ = thickness of face plate, in mm.

### 4.3 Transverse framing

4.3.1 The scantlings of bottom and side frames and deck beams are to comply with the requirements of *Table 4.4.2 Transverse framing*.

### 4.4 Primary supporting structure

4.4.1 Primary supporting members are to comply with the requirements of *Table 4.4.3 Primary supporting structure*

**Table 4.4.2 Transverse framing**

| Position of member | Modulus, in $cm^3$ |
|---|---|
| Bottom and side frames | $Z = 9{,}5\ k\ l_e^{\ 2}\ s\ h \times 10^{-3}$ |
| Deck beams | $Z = 4{,}5\ k\ l_e^{\ 2}\ s\ h \times 10^{-3}$ |
| $h$ as defined in *Pt 3, Ch 4, 1.3 Symbols and definitions 1.3.5*<br>$Z$ = section modules of stiffening member, in $cm^3$, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*<br>$l_e$ = effective length of stiffening member, in metres, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*<br>$s$ = spacing of frames, beams, or longitudinals, in mm<br>$k$ = material factor *see Pt 3, Ch 2, 1.2 Steel* | |

**Table 4.4.3 Primary supporting structure**

| Position of member | Modulus, in $cm^3$ |
|---|---|
| Bottom transverse | $Z = 11{,}0\ k\ l_e^{\ 2}\ S\ h$ |
| Side transverse | $Z = 8{,}0\ k\ l_e^{\ 2}\ S\ h$ |
| Deck transverse | $Z = 5{,}5\ k\ l_e^{\ 2}\ S\ h$ |
| Bottom girder | $Z = 9{,}5\ k\ l_e^{\ 2}\ S\ h$ |

| Deck longitudinal girder | $Z = 5{,}0\ k\ l_e{}^2\ S\ h$ |
|---|---|
| $h$ as defined in *Pt 3, Ch 4, 1.3 Symbols and definitions 1.3.5*<br>$Z$ = section modules of stiffening member, in cm$^3$, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*<br>$l_e$ = effective length of stiffening member, in metres, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*<br>$S$ = spacing or mean spacing of girders, transverses or floors, in metres<br>$k$ = material factor *see Pt 3, Ch 2, 1.2 Steel* | |

### 4.5 Deck beams and longitudinals subject to vehicle loading

4.5.1 The section modulus, $Z$, of deck beams or longitudinals is to be not less than that required to satisfy the most severe arrangement of print wheel loads on the stiffener in association with a bending stress of:

$$\frac{100}{k}\ \mathrm{N/mm^2} \text{ assuming 100 per cent end fixity.}$$

where

$k$ = material factor *see Pt 3, Ch 2, 1.2 Steel*.

### 4.6 Deck girders and transverses subject to vehicle loading

4.6.1 Where the load on deck girders and transverses is uniformly distributed, the section modulus is to be not less than:

$$Z = 4{,}75 b\ h\ l^2_e\ k\ \mathrm{cm}^3$$

where

$h$ is defined in *Pt 3, Ch 4, 1.3 Symbols and definitions 1.3.5*

$l_e$ = effective length of stiffening member, in metres, *see Pt 3, Ch 3, 2 Structural idealization for pontoons*

$b$ = mean width of plating supported by a deck girder or transverse, in metres

$k$ = material factor. *See Pt 3, Ch 2, 1.2 Steel*.

4.6.2 Where the member supports point loads, with or without the addition of uniformly distributed load, the section modulus is to be based on a stress of

$$\frac{123{,}6}{k}\ \mathrm{N/mm^2} \text{ assuming 100 per cent end fixity}$$

where

$k$ = material factor, *see Pt 3, Ch 2, 1.2 Steel*.

4.6.3 Where it is proposed to carry tracked vehicles, the total weight of the vehicle is to be taken when determining the section modulus of the transverse at the top of a ramp or at other changes of gradient.

### 4.7 Direct calculations

4.7.1 As an alternative to *Pt 3, Ch 4, 4.5 Deck beams and longitudinals subject to vehicle loading*and *Pt 3, Ch 4, 4.6 Deck girders and transverses subject to vehicle loading*, permissible deck load capacity may be determined by direct calculation.

### 4.8 Ship ramp loads

4.8.1 The deck plating and underdeck stiffening are to be considered for any loads imposed by ship ramps, where appropriate.

### 4.9 Train decks

4.9.1 Decks for the transport of railway rolling stock on fixed rails will be specially considered.

### 4.10 Heavy or special loads

4.10.1 Where heavy or special loads, such as machinery transporters are proposed to be carried, the scantlings and arrangements of the deck structure will be individually considered.

## ■ *Section 5*
## Bulkheads

### 5.1 General

5.1.1 These requirements cover watertight and ballast tank transverse and longitudinal bulkheads. Requirements are also given for non-watertight pillar bulkheads.

5.1.2 The requirements apply to a vertical system of stiffening on bulkheads. They may also be applied to a horizontal system of stiffening provided that equivalent end support and alignment are provided.

**Table 4.5.1 Watertight and ballast tank bulkhead scantlings**

| Item and requirements | Watertight bulkhead | Ballast tank bulkhead |
|---|---|---|
| (1) Plating thickness for plane, symmetrically corrugated and double plate bulkheads | $t = 0,004s\ f\sqrt{h_4\ k}$ mm<br>but not less than 5,5 mm | $t = 0,004s\ f\sqrt{\frac{\rho\ h_4\ k}{1,025}} + 2,5$ mm<br>but not less than 6,5 mm |
| | In the case of symmetrical corrugations, $s$ is to be taken as $b$ or $c$ in *Figure 3.2.1 Corrugated section* in Ch 3,2 whichever is the greater | |
| (2) Modules of rolled and built stiffeners, swedges, double plate bulkheads and symmetrical corrugations | $Z = \frac{s\ k\ h_4\ l_e^2}{284\ \gamma}$ cm$^3$ | $Z = \frac{\rho\ s\ k\ h_4\ l_e^2}{88\ \gamma}$ cm$^3$ |
| | In the case of symmetrical corrugations, $s$ is to be taken as $p$, *see also* Note 2 | |
| (3) Inertia of rolled and built stiffeners and swedges | – | $I = \frac{2,3}{k}\ l_e\ Z$ cm$^4$ |
| (4) Symmetrical corrugations and double plate bulkheads | Additional requirements to be complied with as detailed in *Table 4.5.2 Symmetrical corrugations and double plate bulkheads (additional requirements)* | |
| (5) Stringers or webs supporting vertical or horizontal stiffening<br>(a) Modules | $Z = 5,5\ k\ h_4\ S\ l_e^2$ cm$^3$ | $Z = 11,7\ \rho\ k\ h_4\ S\ l_e^2$ cm$^3$ |
| (b) Inertia | – | $I = \frac{2,3}{k} l_e\ Z$ cm$^4$ |

| |
|---|
| $s$, $S$, $k$ as defined in *Table 4.3.3 Strength/weather deck plating*<br>$d_w$ = web depth of stiffening member, in mm<br>$f$ = $1,1 - \frac{s}{2500S}$ but not to be taken greater than 1,0<br>$h_4$ = load head, in metres, measured vertically as follows:<br>• For watertight bulkhead plating, the distance from a point one-third of the height of the plate above its lower edge to a point 0,91 m above the bulkhead deck at side<br>• For ballast tank bulkhead plating, the distance from a point one-third of the height of the plate above its lower edge to the top of the tank, or half the distance to the top of the overflow, whichever is greater<br>• For watertight bulkhead stiffeners or girders, the distance from the middle of the effective length to a point 0,91 m above the bulkhead deck side<br>• For ballast tank bulkhead stiffeners or girders, the distance from the middle of the effective length to the top of the tank, or half the distance to the top of the overflow, whichever is the greater<br>$l_e$ = effective length of stiffening member, in metres<br>$\rho$ = spacing of corrugations as shown in Ch 3, *Figure 3.2.1 Corrugated section*<br>$\gamma$ = 1,4 for rolled or built sections and double plate bulkheads<br>= 1,6 for flat bars<br>= 1,1 for symmetrical corrugations of ballast tank bulkheads<br>= 1,0 for symmetrical corrugations of watertight bulkheads |
| Note 1. In no case are the scantlings of ballast tank bulkheads to be less than the requirements for watertight bulkheads.<br>Note 2. In calculating the actual modules of symmetrical corrugations the panel width $b$, is not to be taken greater than that given by *Pt 3, Ch 3, 2.1 Geometric properties of section*<br>Note 3. For rolled or built stiffeners with flanges of face plate, the web thickness is to be not less than $\frac{d_w}{60\sqrt{k}}$ whilst for flat bar stiffeners the web thickness is to be not less than than $\frac{d_w}{18\sqrt{k}}$ . |

### 5.2 Number and disposition of bulkheads

5.2.1 All pontoons (L ≤ 30 m) are to be subdivided by at least two transverse watertight bulkheads and one watertight longitudinal bulkhead. For pontoons where 30 m < L ≤ 65 m, at least three transverse watertight bulkheads and one longitudinal watertight bulkhead, or two transverse and two longitudinal watertight bulkheads are to be fitted.

5.2.2 The bulkheads are to be spaced at reasonably uniform intervals.

5.2.3 The watertight bulkheads are to be the full depth of the pontoon and are to provide support for the weather and vehicle deck.

5.2.4 Watertight recesses or doors in bulkheads are generally to be so framed and stiffened as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

5.2.5 Any machinery spaces inside pontoons are to be protected by watertight bulkheads.

### 5.3 Watertight and ballast tank bulkheads

5.3.1 The scantlings of watertight and ballast tank bulkheads are to comply with the requirements of *Table 4.5.1 Watertight and ballast tank bulkhead scantlings*.

5.3.2 Where bulkhead stiffeners support deck girders, transverses or pillars over, they are also to satisfy the requirements of *Table 4.5.1 Watertight and ballast tank bulkhead scantlings*.

5.3.3 Where watertight bulkhead stiffeners are cut in way of watertight doors in the lower part of a bulkhead, the opening is to be suitably framed and reinforced. Where stiffeners are not cut but the spacing between the stiffeners is increased on account of

watertight doors, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffness of the door frame into consideration. Watertight recesses in bulkheads are generally to be so framed and stiffened as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

**Table 4.5.2 Symmetrical corrugations and double plate bulkheads (additional requirements)**

| Type of bulkhead | Parameter | Watertight bulkheads | Ballast tank bulkheads |
|---|---|---|---|
| Symmetrically corrugated | $\frac{b}{t}$ | Not to exceed: | Not to exceed: |
| | | $85\sqrt{k}$ at top, and | $70\sqrt{k}$ at top, and |
| | | $70\sqrt{k}$ at bottom | at bottom |
| (*see also* Notes 1 and 2) | *d* | — | To be not less than $39 l_e$ mm |
| | θ | To be less than 40° | |
| Double plate | $\frac{s}{t}$ | Not to exceed: | $75\sqrt{k}$ at top, and<br>$65\sqrt{k}$ at bottom |
| | $\frac{d}{t_w}$ | Not to exceed: | $85\sqrt{k}$ at top, and<br>$75\sqrt{k}$ at bottom |
| | *d* | — | To be not less than $39 l_e$ mm |
| | $A_w$ | Not to exceed:<br>$\frac{0,12Z}{l_e}$ cm$^2$ at top.<br>and<br>$\frac{0,18Z}{l_e}$ cm$^2$ at bottom | Not to exceed:<br>$\frac{0,07Z}{l_e}$ cm$^2$ at top.<br>and<br>$\frac{0,10Z}{l_e}$ cm$^2$ at bottom |

*s*, *k* as defined in *Table 4.3.3 Strength/weather deck plating*

$b$ = panel width as in *Pt 3, Ch 3, 2.1 Geometric properties of section 2.1.4*

$d$ = depth, in mm, of symmetrical corrugation or double plate bulkhead

$l_e$ = as defined in *Pt 3, Ch 3, 2.2 Determination of span point*

$A_w$ = shear area, in cm$^2$ of web of double plate bulkhead

θ = angle of web corrugation to plane of bulkhead

Note 1. The plating thickness at the middle of span $l_e$ of corrugated or double plate bulkheads is to extend not less than $0,2 l_e$ m above mid-span.

Note 2. Where the span of corrugations exceeds 15 m, a diaphragm plate is to be arranged at about mid-span.

### 5.4 Corrugated and double plated bulkheads

5.4.1 Where corrugated and double plated bulkheads are fitted in pontoons the additional requirements of *Table 4.5.2 Symmetrical corrugations and double plate bulkheads (additional requirements)* are to be met.

### 5.5 Non-watertight pillar bulkheads

5.5.1 The scantlings of non-watertight pillar bulkheads are to comply with the requirements of *Table 4.5.3 Non-watertight pillar bulkhead*.

**Table 4.5.3 Non-watertight pillar bulkhead**

| Parameter | Requirement | |
|---|---|---|
| (1) Minimum thickness of bulkhead plating | 5,5 mm | |
| (2) Maximum stiffener spacing | 1500 mm | |
| (3) Minimum depth of stiffeners or corrugations | 100 mm | |
| (4) Cross-section area (including plating) for rolled, built or swedged stiffeners supporting beams, longitudinals, girders or transverse | (a) Where $\frac{s}{t} \leq 80$ | $A = A_1$ |
| | (b) Where $\frac{s}{t} \geq 120$ | $A = A_2$ |
| | (c) Where $80 < \frac{s}{t} < 120$ <br> $A$ is obtained by interpolation between $A_1$ and $A_2$ | |
| (5) Cross -sectional area (including plating) for symmetrical corrugations | (a) Where $\frac{b}{t_p} \leq \frac{750\ \lambda\ l_e}{(\lambda + 0,25)r}$ | $A = A_1$ |
| | (b) Where $\frac{b}{t_p} > \frac{750\ \lambda\ l_e}{(\lambda + 0,25)r}$ | $A = A_2$ |

$d_w$, $t_p$, $b$, $c$ as defined in *Pt 3, Ch 3, 2 Structural idealization for pontoons*

$r$ = radius of gyration, in mm of stiffener and attached plating

= $10\sqrt{\frac{I}{A}}$ mm for rolled built or swedged stiffeners

= $d_w\sqrt{\frac{3b + c}{12(b + c)}}$ for symmetrical corrugation

= moment of interia, in cm$^4$, of stiffener and attached plating

$s$ = spacing of stiffeners, in mm

$A$ = cross-sectional area, in cm$^2$, of stiffener and attached plating

$A_1$ = $\frac{P}{12,36 - 51,5\frac{l_e}{r}}$ cm$^2$

= As a first approximation $A_1$ may be taken as $\frac{P}{9,32}$

$A_2$ = $\frac{P}{4,9 - 14,7\frac{l_e}{r}}$ $cm^2$

= As a first approximation $A_2$ may be taken as $\frac{P}{3,92}$

= $P$, $l_e$ as defined in *Table 4.5.4 Pillars*

$\lambda$ = $\frac{b}{c}$

## 5.6 Storage of flammable liquid

5.6.1 Pontoon tanks used for the storage of flammable liquid are to have at least a one tank or dry space separation from the ship interface.

**Table 4.5.4 Pillars**

| Parameter | Requirement |
|---|---|
| (1) Cross-sectional area of all types of pillar | $A_p = \dfrac{k\,P}{12,36 - 51,5\dfrac{l_e}{r\sqrt{k}}}$ cm$^2$<br>*See* note |
| (2) Minimum wall thickness of tubular pillars | The greatest of the following:<br>(a) = $t = \dfrac{P}{0,392 d_p - 4,91 l_e}$ mm<br>(b) = $t = \dfrac{d_p}{40}$ mm<br>(c) = $t = 5,5$ mm |
| (3) Minimum wall thickness of hollow rectangular pillars or web plate thickness of or channel sections | The lesser of the following:<br>(a) = $t = \dfrac{b\,r}{600 l_e}$ mm<br>(b) = $t = \dfrac{d_p}{40}$ mm<br>= $t = 5,5$ mm<br>but not less than |
| (4) Minimum thickness of flanges of angle or channel sections | The lesser of the following:<br>(a) = $t_f = \dfrac{b\,r}{200 l_e}$ mm<br>(b) = $t_f = \dfrac{b}{18}$ mm |
| (5) Minimum thickness of flanges of built or rolled sections | The lesser of the following:<br>(a) = $t_f = \dfrac{b\,r}{400 l_e}$ mm<br>(b) = $t_f = \dfrac{b}{36}$ mm |

| | | |
|---|---|---|
| $b$ | = | breadth of side of a hollow rectangular pillar or breadth of flange or web of a built or rolled section, in mm |
| $d_p$ | = | mean diameter of tubular pillars, in mm |
| $k$ | = | material factor |
| $l$ | = | overall length of pillar in metres |
| $l_e$ | = | effective length of pillar in metres |
| $l_p$ | = | distance, in metres, between centres of the two adjacent spans of girder, or transverse, supported by the pillar |
| $P_a$ | = | load, in kN, from pillar or pillars above (zero if no pillars over) |
| $r$ | = | least radius of gyration of a pillar cross-section, in mm, and may be taken as |
| $r$ | = | $10\sqrt{\frac{I}{A_p}}$ mm |
| $A_p$ | = | cross-sectional area of pillar, in cm$^2$ |
| $S$ | = | as defined in *Table 4.3.3 Strength/weather deck plating* |
| $H_g$ | = | is defined as the equivalent sea water head from disturbed design loads including, vehicles, passengers, ramp loads or ship's ramp load or any combination of these, but is not to be taken less than 0,01$L$ + 0,7m |
| | = | least moment of interia of cross-section, in cm$^4$ |
| $P$ | = | load, in kN, supported by the pillar and is to be taken as 10,06 $S\,H_g\,l_p + P_a$ but not less than 19,62 kN |
| | = | For pillars loaded by concentrated loads from ramps or other structures above $P$, is to be individualy calculated, in kN, for the loads involved including distributed loads |

**Note** As a first approximation $A_p$ may be taken as $\frac{\sqrt{k}\,P}{9,32}$ and the radius of gyration estimated for a suitable section having this area. If the area calculated using this radius of gyration differs by more than 10 per cent from the first approximation, a further calculation using the radius gyration corresponding to the mean area of the first and second approximation is to be made.

## ■ *Section 6* Pillars

### 6.1 General

6.1.1 Pillars are to comply with the requirements of *Table 4.5.4 Pillars*.

6.1.2 Pillars are to be fitted in the same vertical line wherever possible and effective arrangements are to be made to distribute the load at the ends of all pillars. Where pillars support eccentric loads, they are to be strengthened for the additional bending moment imposed upon them.

6.1.3 Pillars of hollow section are to be attached at their heads to plates supported by efficient brackets, in order to transmit the load effectively. Doubling or insert plates are to be fitted to the inner bottom under the heels of hollow pillars, and to decks under large pillars. The pillars are to have a bearing fit and are to be attached to the head and heel plates by continuous welding. At the ends of pillars built of rolled open sections, the load is to be well distributed by means of longitudinal and transverse brackets.

6.1.4 Where pillars are fitted inside tanks the tensile stress in the pillar and its end connections is not to exceed 108 N/mm$^2$ at the test heads. In general, such pillars should be of fabricated sections, and end brackets may be required.

## Section 7
## Welding and structural details

### 7.1 Application

7.1.1 Requirements are given in this Section for the following:

(a) Welding-connection details, defined practices and sequence, consumables and equipment, procedures, workmanship and inspection.
(b) End connection scantlings and constructional details for longitudinals, beams, frames and bulkhead stiffeners.
(c) Primary member proportions, stiffening and construction details.

### 7.2 Welding – general

7.2.1 The plans to be submitted for approval are to indicate clearly details of the welded connections of main structural members, including the type and size of welds. This requirement includes welded connections to steel castings. The information to be submitted should include the following:

(a) Whether weld sizes given are throat thicknesses or leg lengths.
(b) Grades and thicknesses of materials to be welded.
(c) Location, types of joints and angles of abutting members.
(d) Reference to welding procedures to be used.
(e) Sequence of welding of assemblies and joining up of assemblies.

7.2.2 Unless otherwise indicated, all welding is to be in accordance with the requirements of *Ch 13 Requirements for Welded Construction* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

### 7.3 Welding – fillet welds

7.3.1 The throat thickness of fillet welds is to be determined from:

$$\text{Throat thickness} = t_p \text{ x weld factor x } \frac{d}{s}$$

where

$d$ = the distance between start positions of successive weld fillet, in mm

$s$ = the length, in mm, of correctly proportioned weld fillet, clear of end craters, and is to be not less than 75 mm

$t_p$ = plate thickness, on which weld fillet size is based, in mm

*See also Figure 4.7.1 Weld dimensions and types*.

Weld factors are given in *Table 4.7.1 Weld factors*, *Table 4.7.3 Connections of primary structure* and *Table 4.7.4 Secondary member end connection welds*.

7.3.2 Where double continuous fillet welding is proposed, the throat thickness is to be determined taking $\frac{d}{s}$ equal to 1,0.

7.3.3 The leg length of the weld is to be not less $\sqrt{2}$ than times the specified throat thickness.

7.3.4 The plate thickness, $t_p$, to be used in the above calculation is generally to be that of the thinner of the two parts being joined. Where the difference in thickness is considerable, the size of fillet will be considered.

7.3.5 Where the thickness of the abutting member of the connection (e.g. the web of a stiffener) is greater than 15 mm and exceeds the thickness of the table member (e.g. plating), the welding is to be double continuous and the throat thickness of the weld is to be not less than the greatest of the following:

(a) 0,21 times thickness of the table member. The table member thickness used need not exceed 25 mm.
(b) 0,21 (0,27 in tanks) times half the thickness of the abutting member.
(c) As required by *Table 4.7.2 Throat thickness limits*.

7.3.6 Except as permitted by *Pt 3, Ch 4, 7.3 Welding – fillet welds 7.3.5*, the throat thickness of the weld is not to be outside the limits specified in *Table 4.7.2 Throat thickness limits*.

7.3.7 Double continuous fillet welding is to be adopted in the following locations, and may be used elsewhere if desired:

(a) Boundaries of weathertight decks and erections, including hatch coamings, companionways and other openings.
(b) Boundaries of tanks and watertight compartments.
(c) All lap welds in tanks.
(d) Primary and secondary members to plating in way of end connections, and end brackets to plating in the case of lap connections.
(e) Where *Pt 3, Ch 4, 7.3 Welding – fillet welds 7.3.5* applies.
(f) All water ballast tanks.
(g) Other connections or attachments, where considered necessary, and in particular the attachment of minor fittings to higher tensile steel plating.

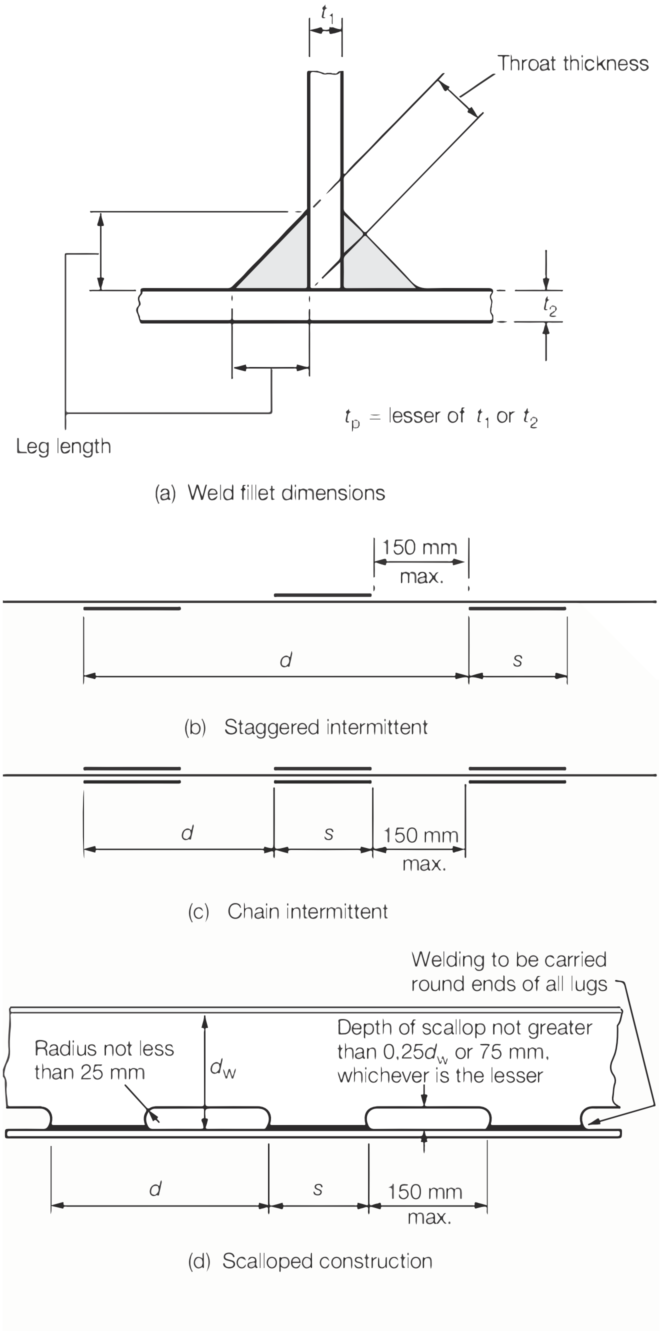



**Figure 4.7.1 Weld dimensions and types**

7.3.8 Where intermittent welding is used, the welding is to be made double continuous in way of brackets, lugs and scallops and at the orthogonal connections with other members.

7.3.9 As an alternative to intermittent welding, single-sided welding may be used. Only mechanised single-sided welding is acceptable although manual single-sided welding may be used at non-critical locations, e.g. deck house stiffeners. Where single-sided welding is used, the welding is to be made double continuous in way of brackets, lugs and scallops and at the orthogonal connections with other members.

7.3.10 Where structural members pass through the boundary of a tank, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for the members for at least 150 mm on each side of the

boundary. Alternatively, a small scallop of suitable shape may be cut in the member close to the boundary outside the compartment, and carefully welded all round.

**Table 4.7.1 Weld factors**

| | Item | | Weld factor | Remarks |
|---|---|---|---|---|
| (1) | General application: | | | except as required below: |
| | Watertight plate boundaries | | 0,34 | |
| | Non-tight plate boundaries | | 0,13 | |
| | Longitudinals, frames, beams and other secondary members to shell, deck or bulkhead plating | | 0,10 | |
| | | | 0,13 | in tanks |
| | | | 0,21 | in way of end connections |
| | Panel stiffeners, etc. | | 0,10 | |
| | Overlap welds generally | | 0,27 | |
| | Longitudinals of the flat-bar type to plating | | | *see* Note 2 |
| (2) | Bottom construction in way of tanks: | | | |
| | Non-tight centre girder: | to keel | 0,27 | |
| | | to bottom | 0,21 | no scallops |
| | | | 0,21 | in way of 0,2 times span at ends |
| | Non-tight boundaries of floors, girders and brackets | | 0,27 | in way of brackets at lower end of main frame |
| | Watertight bottom girders | | 0,34 | |
| | Connection of girder to inner bottom in way of longitudinal bulkheads supported on inner bottom | | 0,44 | |
| | Connection of floors to inner bottom in way of plane bulkheads, bulkhead stools or corrugated and double plate bulkheads supported on inner bottom. The supporting floors are to be continuously welded to the inner bottom | | 0,44 | Weld material compatible with floor material |
| (3) | Hull framing: | | | |
| | Webs of web frames: | to shell | 0,16 | |
| | | to face plate | 0,13 | |
| | Tank side brackets to shell and inner bottom | | 0,34 | |
| (4) | Decks and supporting structure: | | | |
| | Strength deck plating to shell | | | As shown in *Table 4.7.5 Weld connection of strength deck plating to sheerstrake* but alternative proposals will be considered |

| | | | | |
|---|---|---|---|---|
| | Webs of cantilevers to deck and to shell in way of root bracket | | 0,44 | |
| | Webs of cantilevers to face plate | | 0,21 | |
| | Pillars: | fabricated | 0,10 | |
| | | end connections | 0,34 | *see* Note 1 |
| | | end connections (tubular) | full penetration | |
| | Girder web connections and brackets in way of pillar heads and heels | | | continuous |
| (5) | Bulkheads and tank construction: | | | |
| | Plane, double plate and corrugated watertight bulkhead boundary at bottom, bilge, inner bottom, deck and connection to shelf plate, where fitted | | 0,44 | weld size to be based on thickness of bulkhead plating<br>weld material to be compatible with bulkhead plating material |
| | Shelf plate connection to stool | | 0,44 | weld size to be based on thickness of bulkhead plating<br>weld material to be compatible with bulkhead plating material |
| | Plane, double plate and corrugated bulkhead boundaries in way of deep tanks: | | | |
| | - Boundary at bottom, bilge, inner bottom and deck | | 0,44 | |
| | - Connection of stool and bulkhead to lower stool shelf plating | | full penetration | |
| | - Connection of stool and bulkhead plating to upper stool shelf plate | | 0,44 | |
| | - Connection of bulkhead plating to hopper and topside tanks | | 0,44 | |
| | - Connection of bulkhead plating to side shell | | 0,34 | |
| | Secondary members where acting as pillars | | 0,13 | |
| | Non-watertight pillar bulkhead boundaries | | 0,13 | |
| | Perforated flats and wash bulkhead boundaries | | 0,10 | |
| (6) | Structure in pump room: | | | |
| | Centre girder to keel and inner bottom | | 0,27 | |
| | Floors to centre girder in way of machinery seating | | 0,27 | |
| | Floors and girders to shell and inner bottom | | 0,21 | |
| | Machinery seating to supporting structure | | 0,21 | |
| | Transverse and longitudinal framing to shell | | 0,13 | |
| (7) | Miscellaneous fittings and equipment: | | | |
| | Rings for manhole type covers, to deck or bulkhead | | 0,34 | |

| | | | |
|---|---|---|---|
| | Primary and secondary stiffening of tank covers | 0,13 | |
| | Ventilator, air pipe, etc. coamings to deck and fittings | 0,21 | |
| | Scuppers and discharges, to deck | 0,44 | |
| | Deck machinery seats to deck | 0,21 | generally |
| | Mooring equipment seats | 0,21 | generally, but increased or full penetration welding may be required |
| | Guard rails, stanchions, etc. to deck | 0,34 | |

Note 1. Where pillars are fitted inside tanks or under watertight flats, the end connection is to be such that the tensile stress in the weld does not exceed 108 N/mm$^2$.

Note 2. The throat thickness of the weld is to be determined by *Pt 3, Ch 4, 7.3 Welding – fillet welds 7.3.5*. For longitudinals within D/4 of the strength deck and with a thickness less than 100 mm, the throat thickness need not exceed 5,5 mm.

### 7.4 Welding of primary structure

7.4.1 Weld factors for the connections of primary structure are given in *Table 4.7.3 Connections of primary structure*.

7.4.2 The weld connection to shell, deck or bulkhead is to take account of the material lost in the notch where longitudinals or stiffeners pass through the member. Where the width of notch exceeds 15 per cent of the stiffener spacing, the weld factor is to be multiplied by:

$$\frac{0{,}85 \times \text{stiffener spacing}}{\text{length of web plating between notches}}$$

7.4.3 Where direct calculation procedures have been adopted, the weld factors for the 0,2 x overall length at the ends of the members will be considered in relation to the calculated loads.

7.4.4 The throat thickness limits given in *Table 4.7.2 Throat thickness limits* are to be complied with.

**Table 4.7.2 Throat thickness limits**

| Item | | Throat thickness, in mm | |
|---|---|---|---|
| | | Minimum | Maximum |
| (1) | Double continuous welding | $0{,}21t_p$ | $0{,}44t_p$ |
| (2) | Intermittent welding | $0{,}27t_p$ | $0{,}44t_p$ or 4,5 |
| (3) | All welds, overriding minimum | | |
| (a) | Plate thickness $t_p \leq 7{,}5$ mm | | |
| | Hand or automatic welding | 3,0 | - |
| | Automatic deep penetration welding | 3,0 | - |
| (b) | Plate thickness $t_p > 7{,}5$ mm | | |
| | Hand or automatic welding | 3,25 | - |

| | | | |
|---|---|---|---|
| | Automatic deep penetration welding | 3,0 | - |

Note 1. In all cases, the limiting value is to be taken as the greatest of the applicable values given above.

Note 2. Where $t_p$ exceeds 25 mm, the limiting values can be calculated using a notional thickness equal to 0,4($t_p$ + 25) mm, but is not to be taken as less than 25 mm.

Note 3. The maximum throat thicknesses shown are intended only as a design limit for the approval of fillet welded joints. Any welding in excess of these limits is to be to the Surveyor's satisfaction.

**Table 4.7.3 Connections of primary structure**

| Primary member face area, in $cm^2$ | | | Weld factor | | | |
|---|---|---|---|---|---|---|
| Exceeding | Not exceeding | Position *see* Note 1 | In tanks | | In dry spaces | |
| | | | To face plate | To plating | To face plate | To plating |
| | 30,0 | At ends | 0,21 | 0,27 | 0,21 | 0,21 |
| | | Remainder | 0,10 | 0,16 | 0,10 | 0,13 |
| 30,0 | 65,0 | At ends | 0,21 | 0,34 | 0,21 | 0,21 |
| | | Remainder | 0,13 | 0,27 | 0,13 | 0,16 |
| 65,0 | 95,0 | At ends | 0,34 | 0,44 *see* Note 2 | 0,21 | 0,27 |
| | | Remainder | 0,27 | 0,34 | 0,16 | 0,21 |
| 95,0 | 130,0 | At ends | 0,34 | 0,44 *see* Note 2 | 0,27 | 0,34 |
| | | Remainder | 0,27 | 0,34 | 0,21 | 0,27 |
| 130,0 | | At ends | 0,44 | 0,44 *see* Note 2 | 0,34 | 0,44 *see* Note 2 |
| | | Remainder | 0,34 | 0,34 | 0,27 | 0,34 |

Note 1. The weld factors ‘at ends' are to be applied for 0,2 times the overall length of the member from each end, but at least beyond the toes of the member end brackets. On vertical webs the increased welding may be omitted at the top but is to extend at least 0,3 times the overall length from the bottom.

Note 2. Where the web plate thickness is increased locally, the weld size may be based on the thickness clear of the increase but is to be not less than 0,34 times the increased thickness.

**Table 4.7.4 Secondary member end connection welds**

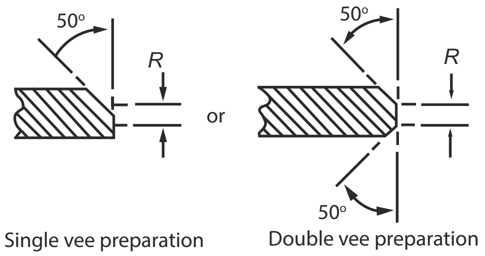
| Connection | Weld area, $A_w$, in $cm^2$ | Weld factor |
|---|---|---|
| (1) Stiffener welded direct to plating | 0,25$A_s$ or 6,5 $cm^2$ whichever is the greater | 0,34 |
| (2) Bracketless connection of stiffeners or stiffener lapped to bracket or bracket lapped to stiffener: | | 0,27 |
| (a) In dry space | $1{,}2\sqrt{Z}$ | 0,34 |
| (b) In tank | $142\sqrt{Z}$ | 0,34 |
| (3) Bracket welded to face of stiffener and bracket connection to plating | - | 0,34 |
| (4) Stiffener to plating for 0,1 times span at ends, or in way of end bracket if that be greater | - | 0,34 |

| Symbols |
| --- |
| $A_s$ = cross-sectional area of the stiffener, in cm$^2$<br>$A_w$ = the area of the weld, in cm$^2$, and is calculated as total length of weld, in cm, times throat thickness, in cm<br>$Z$ = the section modulus, in cm$^2$, of the stiffener on which the scantlings of the bracket are based, *see Pt 3, Ch 4, 7.8 Secondary member end connections* |
| Note For maximum and minimum weld fillet sizes, *see Table 4.7.2 Throat thickness limits*. |

**Table 4.7.5 Weld connection of strength deck plating to sheerstrake**

| Item | Deck stringer plate thickness, mm | Weld type |
| --- | --- | --- |
| 1 | $t \leq 15$ | Double continuous fillet weld with a weld factor of 0,44 |
| 2 | $15 < t \leq 20$ | Single vee preparation to provide included angle of 50° with root $R \leq \frac{1}{3}t$ in conjunction with a continuous fillet weld having a weld factor of 0,39; or<br>Double vee preparation to provide included angles of 50° with root $R \leq \frac{1}{3}t$ |
| 3 | $t > 20$ | Double vee preparation to provide included angles of 50° with root $R \leq \frac{1}{3}t$ but not to exceed 10 mm |

Where $t$ = thickness of stringer plate, in mm




Note 1. Welding procedure, including joint preparation, is to be specified. Procedure is to be qualified and approved for individual Builders.

Note 2. *See also Pt 3, Ch 4, 7.3 Welding – fillet welds 7.3.10*.

Note 3. For thickness $t$ in excess of 20 mm the deck stringer plate can be bevelled to achieve a reduced thickness at the weld connection. The length of the bevel is in general to be based on a taper not exceeding 1 in 3 and the reduced thickness is in general to be not less than 0,65 times the thickness of the deck stringer plate or 20 mm, whichever is the greater.

Note 4. Alternative connections will be considered.

### 7.5 Welding of primary and secondary end connections

7.5.1 Welding of end connections of primary members is to be such that the area of welding is not less than the cross-sectional area of the member, and the weld factor is to be not less than 0,34 in tanks or 0,27 elsewhere.

7.5.2 The welding of secondary member end connections is to be not less than as required by *Table 4.7.4 Secondary member end connection welds*. Where two requirements are given, the greater is to be complied with.

7.5.3 The area of weld, $A_w$, is to be applied to each arm of the bracket or lapped connection.

7.5.4 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the area of weld is to be not less than the cross-sectional area of the member.

7.5.5 Where the secondary member passes through, and is supported by, the web of a primary member, the weld connection is to comply with the requirements of *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members*

7.5.6 The throat thickness limits given in *Table 4.7.2 Throat thickness limits* are to be complied with.

### 7.6 Welding equipment, consumables and procedure

7.6.1 Welding plant and equipment are to be in accordance with the requirements specified in *Ch 13, 1.8 Welding equipment and welding consumables* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

7.6.2 Welding consumables and associated equipment are to be in accordance with the requirements specified in *Ch 13, 1.8 Welding equipment and welding consumables* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

7.6.3 Welding procedures are to be established for the welding of all joints in accordance with the requirements specified in *Ch 13, 1.9 Welding procedure and welder qualifications* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

7.6.4 All welding procedures are to be tested and qualified in accordance with the requirements of *Ch 12 Welding Qualifications* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020* and are to be approved by the Surveyor prior to construction.

7.6.5 Welders and welding operators are to be proficient in the type of work to be undertaken and are to be qualified in accordance with the requirements specified in *Ch 12 Welding Qualifications* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

7.6.6 A sufficient number of skilled supervisors is to be provided to ensure an effective and systematic control at all stages of welding operations.

### 7.7 Inspection of welds

7.7.1 Effective arrangements are to be provided by the Shipbuilder for the inspection of finished welds to ensure that all welding has been satisfactorily completed.

7.7.2 All finished welds are to be subjected to non-destructive examination (NDE) by personnel designated by the Builder in accordance with the requirements specified in *Ch 13, 2.12 Non-destructive examination of welds* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

7.7.3 In addition to the requirements of *Pt 3, Ch 4, 7.7 Inspection of welds 7.7.2*, a number of checkpoints are to be examined by volumetric examination as detailed in *Pt 3, Ch 4, 7.7 Inspection of welds 7.7.4* to *Pt 3, Ch 4, 7.7 Inspection of welds 7.7.9*.

7.7.4 Typical locations and number of checkpoints to be taken are shown in *Table 4.7.6 Checkpoint locations*.

7.7.5 Checkpoints are not to be identified on the ship's structural components prior to the welding taking place.

7.7.6 For ultrasonic examination the length of each checkpoint is to be 0,5 m and for radiographic examination the length is to be a minimum of 0,3 m. At weld intersections, examination is to be in both weld directions.

7.7.7 The Builder is to provide the Surveyor with all the NDE reports of the checkpoints. These reports are to be available for the Surveyor to review within a short time after inspection, normally considered to be within 10 working days of the examination being carried out. Where welds are repaired, the NDE report is to include details of examination of both the defective weld and of the re-weld.

7.7.8 Where the Surveyor notes that a checkpoint has been repaired without record of the original defect, the Shipyard is to carry out additional examinations on additional lengths of weld. These lengths are to be adjacent to and on both sides of the defective checkpoint. These additional examinations are to be carried out in the presence of the Surveyor and reported in accordance with *Pt 3, Ch 4, 7.7 Inspection of welds 7.7.7*.

7.7.9 Where checkpoints are found to contain continuous or semi-continuous defects, additional lengths of weld adjacent to and on both sides of the defective length are to be subject to further volumetric examination. The NDE reports are to be submitted in accordance with *Pt 3, Ch 4, 7.7 Inspection of welds 7.7.7*.

**Table 4.7.6 Checkpoint locations**

| Item | Location | Checkpoints |
| --- | --- | --- |
| Intersections of butts and seams of fabrication and section welds | Throughout<br>(a) hull envelope, shell envelope and deck structure plating:<br>• at highly stressed areas, *see* Note 1<br>• remainder<br>(b) longitudinal and transverse bulkheads<br>(c) inner bottom plating: | <br><br>all<br>1 in 2<br>1 in 2<br>1 in 2 |
| Butt welds in plating | Throughout | 1 m in 25 m, *see* Notes 2 and 3 |
| Seam welds in plating | Throughout | 1 m in 100 m |
| Butt welds in longitudinals | Hull envelope within 0,4*L* amidships<br>Hull envelope outside 0,4*L* amidships | 1 in 10 welds, *see* Note 4<br>1 in 20 welds |
| Bilge keel butt welds | Within 0,4*L* amidships<br>Remainder | all<br>1 in 3 |
| Structural items when made with full penetration welding as follows: | Throughout | |
| connection of stool and bulkhead to lower stool shelf plating | | 1 m in 20 m |
| vertical corrugations to an inner bottom | | 1 m in 20 m |
| hopper knuckles | | 1 m in 10 m |
| sheerstrake to deck stringer | | 1 m in 20 m |
| hatchways coaming to deck | Hatchway ends within 0,4*L* amidships<br>Hatchway ends outside 0,4*L* amidships<br>Remainder | all<br>1 in 2<br>1 in 40 m |

Note 1. Typically those at sheerstrake, deck stringer, keel strake and turn of bilge.

Note 2. Checkpoints in butt welds and seam welds are in addition to those at intersections.

Note 3. Welds at inserts used to close openings in hull envelope plating are to be checked by NDE.

Note 4. Particular attention is to be given to repair rates in butt welds in longitudinals. Additional welds are to be tested if defects such as lack of fusion or incomplete penetration are observed in more than 10 per cent of the welds examined.

### 7.8 Secondary member end connections

7.8.1 Secondary members, i.e. longitudinals, beams, frames and bulkhead stiffeners forming part of the hull structure, are generally to be connected at their ends in accordance with the requirements of this sub-Section. Where it is desired to adopt bracketless connections, the proposed arrangements will be individually considered.

7.8.2 Where end connections are fitted in accordance with these requirements, they can be taken into account in determining the effective span of the member.

7.8.3 Where the section modulus of the secondary member on which the bracket is based (*Pt 3, Ch 4, 7.8 Secondary member end connections 7.8.5* and *Pt 3, Ch 4, 7.8 Secondary member end connections 7.8.6*) exceeds 2000 cm$^3$, the scantlings of the connection will be considered.

7.8.4 The symbols used in this sub-Section are defined as follows:

$a$, $b$ = the actual lengths of the two arms of the bracket, in mm, measured from the plating to the toe of the bracket

$b_f$ = the breadth of the flange, in mm

$t$ = the thickness of the bracket, in mm

$Z$ = the section modulus of the secondary member, in $cm^3$.

7.8.5 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the scantlings of the brackets are to be such that their section modulus and effective cross-sectional area are not less than those of the member. Care is to be taken to ensure correct alignment of the brackets on each side of the primary member.

7.8.6 In other cases the scantlings of the bracket are to be based on the modulus as follows:

(a) Bracket connecting stiffener to primary member: modulus of the stiffener.
(b) Bracket at the head of a main transverse frame where frame terminates: modulus of the frame.
(c) Elsewhere: the lesser modulus of the members being connected by the bracket.

7.8.7 Typical arrangements of stiffener end brackets are shown diagrammatically in *Figure 4.7.2 Diagrammatic arrangements of stiffener end brackets*.

7.8.8 The lengths, $a$ and $b$, of the arms of end brackets are to be measured from the plating to the toe of the bracket and are to be such that:

(a) $a + b \geq 2{,}0l$
(b) $a \geq 0{,}8l$
(c) $b \geq 0{,}8l$

where

$$l = 90\left(2\sqrt{\frac{z}{14+\sqrt{z}}} - 1\right) \text{ mm}$$

but in no case is $l$ to be taken as less than twice the web depth of the stiffener on which the bracket scantlings are to be based.

7.8.9 The length of arm of tank side and hopper side brackets is to be not less than 20 per cent greater than that required above.

7.8.10 The thickness of the bracket is to be not less than as required by *Table 4.7.7 Thickness of brackets*.

7.8.11 The free edge of the bracket is to be stiffened where any of the following apply:

- The section modulus, $Z$, exceeds 2000 $cm^3$.
- The length of free edge exceeds $50t$ mm.
- The bracket is fitted at the lower end of main transverse side framing.

7.8.12 Where a flange is fitted, its breadth is to be not less than:

$$b_f = 40\left(1 + \frac{Z}{1000}\right) \text{ mm}$$

but not less than 50 mm

7.8.13 Where the edge is stiffened by a welded face flat, the cross-sectional area of the face flat is to be not less than:

(a) $0{,}009 b_f t$ $cm^2$ for offset edge stiffening.
(b) $0{,}014 b_f t$ $cm^2$ for symmetrically placed stiffening.

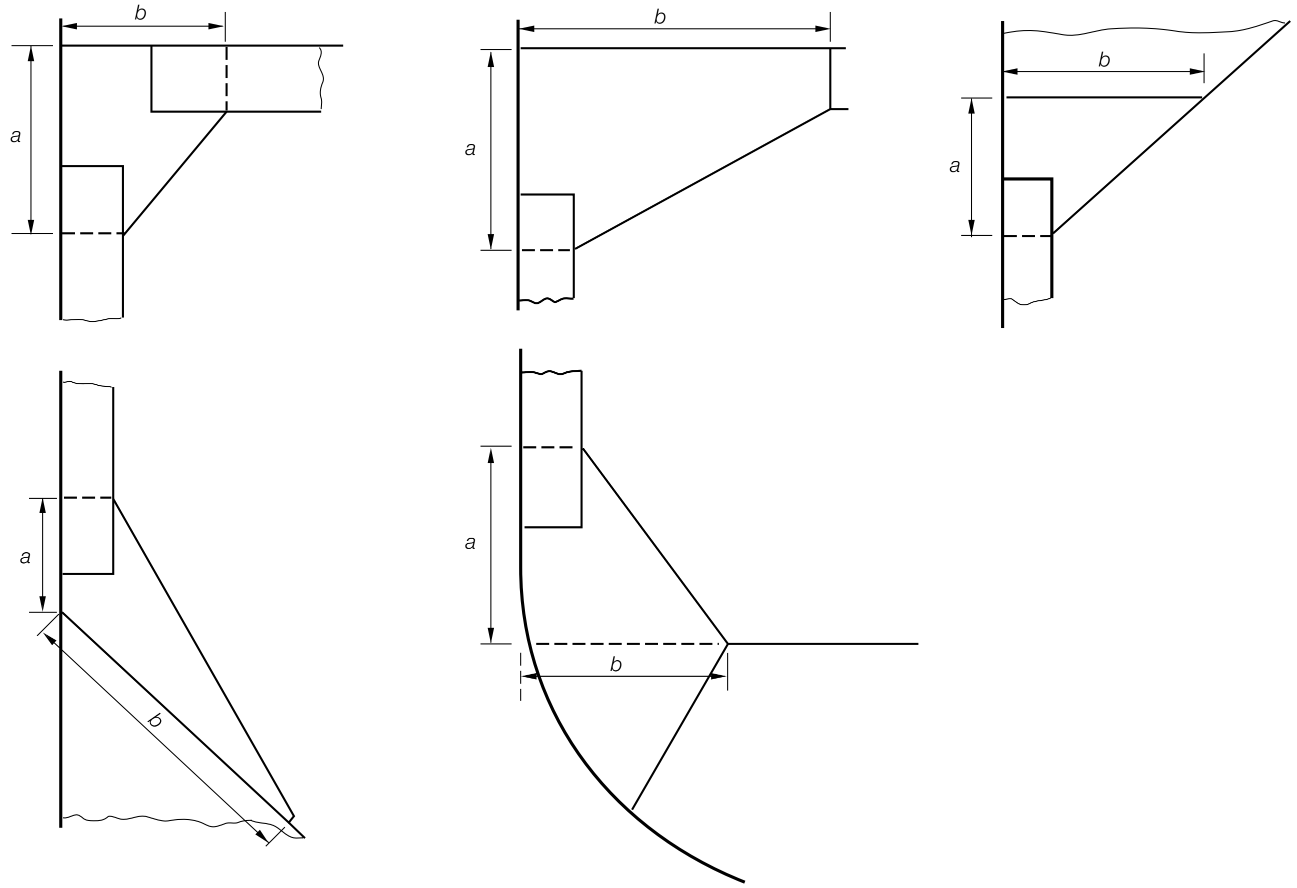



**Figure 4.7.2 Diagrammatic arrangements of stiffener end brackets**

**Table 4.7.7 Thickness of brackets**

| Bracket | Thickness, in mm | Limits | |
|---|---|---|---|
| | | Minimum | Maximum |
| With edge stiffened: | | | |
| (a) in dry spaces | $3,5 + 0,25\sqrt{Z}$ | 6,5 | 12,5 |
| (b) in tanks | $4,5 + 0,25\sqrt{Z}$ | 7,5 | 13,5 |
| Unstiffened brackets | | | |
| (a) in dry spaces | $5,5 + \frac{Z}{55} - \left(\frac{Z}{168}\right)^{1,3}$ | 7,5 | - |
| (b) in tanks | $6,5 + \frac{Z}{55} - \left(\frac{Z}{168}\right)^{1,3}$ | 8,5 | - |

7.8.14 Where the stiffening member is lapped on to the bracket, the length of overlap is to be adequate to provide for the required area of welding. In general, the length of overlap should be not less than $10\sqrt{Z}$ or the depth of stiffener, whichever is the greater.

7.8.15 Where the free edge of the bracket is hollowed out, it is to be stiffened or increased in size to ensure that the modulus of the bracket through the throat is not less than that of the required straight edged bracket.

7.8.16 The arrangement of the connection between the stiffener and the bracket is to be such that at no point in the connection is the modulus reduced to less than that of the stiffener with associated plating.

7.8.17 The design of end connections and their supporting structure is to be such as to provide adequate resistance to rotation and displacement of the joint.

7.8.18 For arrangements where end brackets are not perpendicular to the adjacent plating the strength of the brackets, in terms of lateral stability, may need to be specially considered.

### 7.9 Construction details for primary members

7.9.1 The requirements for section modulus and inertia (if applicable) of primary members are given in *Pt 3, Ch 4, 4 Hull envelope framing*. This Section includes the requirements for proportions, stiffening and construction details for primary members in dry spaces and in tanks.

7.9.2 The requirements of this sub-Section can be modified where direct calculation procedures are adopted to analyse the stress distribution in the primary structure.

7.9.3 The symbols used in this sub-Section are defined as follows:

$d_w$ = depth of member web, in mm

$k$ = higher tensile steel factor, *see Pt 3, Ch 2, 1.2 Steel*

$t_w$ = thickness of member web, in mm

$A_f$ = area of member face plate or flange, in cm$^2$

$S_w$ = spacing of stiffeners on member web, or depth of unstiffened web, in mm.

7.9.4 Primary members are to be so arranged as to ensure effective continuity of strength, and abrupt changes of depth or section are to be avoided. Where members abut on both sides of a bulkhead, or on other members, arrangements are to be made to ensure that they are in alignment. Primary members in tanks are to form a continuous line of support and wherever possible, a complete ring system.

7.9.5 The members are to have adequate lateral stability and web stiffening and the structure is to be arranged to minimise hard spots and other sources of stress concentration. Openings are to have well rounded corners and smooth edges and are to be located having regard to the stress distribution and buckling strength of the panel.

7.9.6 Primary members are to be provided with adequate end fixity by end brackets or equivalent structure. The design of end connections and their supporting structure is to be such as to provide adequate resistance to rotation and displacement of the joint and effective distribution of the load from the member.

7.9.7 Where the primary member is supported by structure which provides only a low degree of restraint against rotation, the member is generally to be extended for at least two frame spaces, or equivalent, beyond the point of support before being tapered.

7.9.8 Where primary members are subject to concentrated loads, particularly if these are out of line with the member web, additional strengthening could be required.

7.9.9 The geometric properties of the members are to be calculated in association with an effective width of attached plating determined in accordance with *Pt 3, Ch 3, 2.1 Geometric properties of section*.

7.9.10 The minimum thickness or area of material in each component part of the primary member is given in *Table 4.7.8 Minimum thickness of primary members*.

7.9.11 Primary members constructed of higher tensile steel are to comply with *Table 4.7.8 Minimum thickness of primary members*.

7.9.12 Primary members are to be supported by tripping brackets. The tripping brackets supporting asymmetrical sections are to be spaced no more than two secondary frames apart. The tripping brackets supporting symmetrical sections are to be spaced no more than four secondary frames apart.

7.9.13 Tripping brackets are also to be fitted at the toes of end brackets and in way of heavy or concentrated loads such as the heels of pillars.

**Table 4.7.8 Minimum thickness of primary members**

| Item | Requirement |
| --- | --- |
| (1) Member web plate, *see* Note | $t_w = 0{,}01 S_w$<br>but not less than 7 mm in dry spaces and 8 mm in tanks |
| (2) Member face plate | $A_t \leq \frac{d_w t_w}{150}$ |
| (3) Deck plating forming the upper flange of underdeck girders | $t \geq \sqrt{\frac{A_f}{1,8k}}$<br>and 10 per cent greater for hatch side girders.<br>Width of plate is to be not less than 700 mm |
| **Note** For primary members having a web depth exceeding 1500 mm, the arrangement of stiffeners will be individually considered, and stiffening parallel to the member face plate could be required. | |

7.9.14 Where the ratio of unsupported width of face plate (or flange) to its thickness exceeds 16:1, the tripping brackets are to be connected to the face plate and on members of symmetrical section the brackets are to be fitted on both sides of the web.

7.9.15 Intermediate secondary members can be welded directly to the web or connected by lugs.

7.9.16 Where the depth of web of a longitudinal girder at the strength deck within 0,4$L$ amidships exceeds $55 t_w \sqrt{k}$ additional longitudinal web stiffeners are to be fitted at a spacing not exceeding the value given in (a) or (b) as appropriate, with a maximum of $65 t_w \sqrt{k}$ for higher tensile steel members. In cases where this spacing is exceeded, the web thickness is, in general, to be suitably increased.

7.9.17 The arm length of unstiffened end brackets is not to exceed 100$t_w$. Stiffeners parallel to the bracket face plate are to be fitted where necessary to ensure that this limit is not exceeded.

7.9.18 Web stiffeners can be flat bars of thickness $t_w$ and depth 0,1$d_w$, or 50 mm, whichever is the greater. Alternative sections of equivalent moment of inertia can be adopted.

7.9.19 Where openings are cut in the web, the depth of opening is not to exceed 25 per cent of the web depth, and the opening is to be so located that the edges are not less than 40 per cent of the web depth from the face plate. The length of opening is not to exceed the web depth or 60 per cent of the secondary member spacing, whichever is the greater, and the ends of the openings are to be equidistant from the corners of cut-outs for secondary members. Where larger openings are proposed, the arrangements and compensation required will be considered.

7.9.20 Openings are to have smooth edges and well-rounded corners.

7.9.21 Cut-outs for the passage of secondary members are to be designed to minimise the creation of stress concentrations. The breadth of cut-out is to be kept as small as practicable and the top edge is to be rounded, or the corner radii made as large as practicable. The extent of direct connection of the web plating, or the scantlings of lugs or collars, is to be sufficient for the load to be transmitted from the secondary member.

7.9.22 End connections of primary members are generally to comply with the requirements for secondary member end connections, taking $Z$ as the section modulus of the primary member.

7.9.23 The thickness of the bracket is to be not less than that of the primary member web. The free edge of the bracket is to be stiffened.

7.9.24 Where a deck girder or transverse is connected to a vertical member on the shell or bulkhead, the scantlings of the latter could be required to be increased to provide adequate stiffness to resist rotation of the joint.

7.9.25 Where a member is continued over a point of support, such as a pillar or pillar bulkhead stiffener, the design of the end connection is to be such as to ensure the effective distribution of the load into the support. Proposals to fit brackets of reduced scantlings, or alternative arrangements, will be considered.

7.9.26 Connections between primary members forming a ring system are to minimise stress concentrations at the junctions. Integral brackets are generally to be radiused or well-rounded at their toes. The arm length of the bracket, measured from the face of the member, is to be not less than the depth of the smaller member forming the connection.

### 7.10 Continuity and alignment

7.10.1 The arrangement of material is to be such as will ensure structural continuity. Abrupt changes of shape or section, sharp corners and points of stress concentration are to be avoided.

7.10.2 Where members abut on both sides of a bulkhead or similar structure, care is to be taken to ensure good alignment.

7.10.3 Pillars and pillar bulkheads are to be fitted in the same vertical line wherever possible, and elsewhere arrangements are to be made to transmit the out of line forces satisfactorily. The load at head and heel of pillars is to be effectively distributed and arrangements are to be made to ensure the adequacy and lateral stability of the supporting members.

7.10.4 Continuity is to be maintained where primary members intersect and where the members are of the same depth, a suitable gusset plate is to be fitted.

7.10.5 End connections of structural members are to provide adequate end fixity and effective distribution of the load into the supporting structure.

7.10.6 The toes of brackets etc. should not land on unstiffened panels of plating. Special care should be taken to avoid notch effects at the toes of brackets, by making the toe concave or otherwise tapering it off.

7.10.7 Where primary and/or secondary members are constructed of higher tensile steel, particular attention is to be paid to the design of the end bracket toes in order to minimise stress concentrations. Sniped face plates which are welded onto the edge of primary member brackets are to be carried well around the radiused bracket toe and are to incorporate a taper not exceeding 1 in 3. Where sniped face plates are welded adjacent to the edge of primary member brackets, an adequate cross-sectional area is to be provided through the bracket toe at the end of the snipe. In general, this area measured perpendicular to the face plate, is to be not less than 60 per cent of the full cross-sectional area of the face plate, *see Figure 4.7.3 Bracket toe construction*.

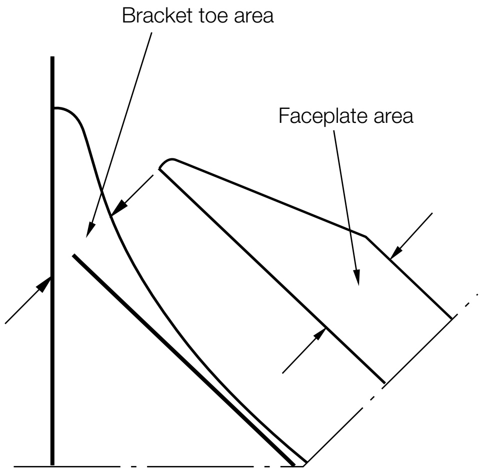



**Figure 4.7.3 Bracket toe construction**

### 7.11 Arrangements at intersections of continuous secondary and primary members

7.11.1 Cut-outs for the passage of secondary members through the web of primary members, and the related collaring arrangements, are to be designed to minimise stress concentrations around the perimeter of the opening and in the attached hull envelope or bulkhead plating. The critical shear buckling stress of the panel in which the cut-out is made is to be investigated. Cut-outs for longitudinals will be required to have double lugs in areas of high stress, e.g. in way of cross tie ends.

7.11.2 Cut-outs are to have smooth edges, and the corner radii are to be as large as practicable, with a minimum of 20 per cent of the breadth of the cut-out or 25 mm, whichever is the greater. It is recommended that the web plate connection to the hull envelope or bulkhead should end in a smooth tapered 'soft toe'. Recommended shapes of cut-out are shown in *Figure 4.7.5 Cut-outs and connections*, but consideration will be given to other shapes on the basis of maintaining equivalent strength and minimising stress concentration. Consideration is to be given to the provision of adequate drainage and unimpeded flow of air and water when designing the cut-outs and connection details.

7.11.3 Asymmetrical secondary members are to be connected on the heel side to the primary member web plate. Additional connection by lugs on the opposite side could be required.

7.11.4 Symmetrical secondary members are to be connected by lugs on one or both sides, as necessary.

7.11.5 The cross-sectional areas of the connections are to be determined from the proportion of load transmitted through each component in association with its appropriate permissible stress.

7.11.6 The total load $P$, in kN, transmitted to the primary member is to be derived in accordance with *Table 4.7.9 Total load transmitted to connection of secondary members*.

7.11.7 This load is to be apportioned between the connections as follows:

(a) Transmitted through the collar arrangement:

$$P_1 = P\left(\frac{S_1}{S_w} + \frac{A_l}{4C_f A_f + A_l}\right)$$

where $A_l$ is derived in accordance with *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.8* and is not to be taken as greater than 0,25.

The collar load factor, $C_f$, is to be derived as follows:

Symmetrical secondary members

| | |
|---|---|
| $C_f$ = 1,85 | for $A_f \leq 18$ |
| $C_f$ = 1,85 - 0,0341($A_f$ -18) | for 18 < $A_f \leq 40$ |
| $C_f$ = 1,1 - 0,01 ($A_f$ - 40) | for $A_f$ > 40 |

Asymmetrical secondary members

$$C_f = 0{,}68 + 0{,}0224\frac{b_l}{A_f}$$

where

$A_f$ = the area, in cm$^2$, of the primary member web stiffener in way of the connection including backing bracket, where fitted (*see Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.10*)

$b_l$ = the length of lug or direct connection, in mm, as shown in *Figure 4.7.5 Cut-outs and connections*. Where the lug or direct connections differ in length, a mean value of $b_l$ is to be used.

(b) Transmitted through the primary member web stiffener:

$$P_2 = P - P_1$$

(c) Where the web stiffener is not connected to the secondary member, $P_1$, is to be taken equal to $P$.

**Table 4.7.9 Total load transmitted to connection of secondary members**

| Head, $h_1$, in metres | Total load, *P* in kN, transmitted to connection |
|---|---|
| Side and bottom shell longitudinals<br>$h_1$ = load height, in metres, derived in accordance with the following provisions, but to be taken as not less than the greater of $\frac{L_1}{70}$ or 1,20 m.<br>(a) With mid-point of span at base line, $h_1 = 0{,}8D_2$<br>(b) With mid-point of span at a distance $0{,}6D_2$ above base line, $h_1 = f\, D_2\, B_f$<br>(c) With mid-point of span intermediate between (a) and (b). The value of $h_1$ is to be obtained by linear interpolation between values from (a) and (b).<br>(d) With mid-point of span higher than $0{,}6D_2$ above base line. The value of $h_1$ is to be obtained by linear interpolation between the value from (b) and zero at the level of the deck edge amidships. | (a) In general<br>$P = 10{,}06(S_w - s_1/2)\, s_1\, h_1$ kN |
| Secondary stiffening members of transverse and longitudinal bulkheads<br>$h_1$ = distance from the mid-point of span to top of tank but need not exceed $0{,}8D_2$ | |
| Symbols | |
| $B_f$ = bow fullness factor, to be taken as 1<br>$f$ = load height factor at level 0,6*D*, *see Table 4.7.10 Load height factor, f*<br>$h_1$ = load height, in metres, *see also Figure 4.7.4 Load height diagram for framing members*<br>$S_w$ = spacing of primary members, in metres<br>$s_1$ = spacing of secondary members, in metres<br>$D_2$ = *D* in metres, but need not be taken greater than 1,6*T*<br>$L_1$ = *L* but need not be taken as greater than 190 m | |

**Table 4.7.10 Load height factor, *f***

| | Ship depth, *D*, in metres | | | | | |
|---|---|---|---|---|---|---|
| | ≤17,5 | 20 | 22,5 | 25 | 27,5 | 30 |
| (1) At and abaft of 0,2*L* from the forward perpendicular | 0,6 | 0,6 | 0,582 | 0,556 | 0,535 | 0,517 |
| (2) Forward of 0,15*L* from the forward perpendicular | 0,7 | 0,685 | 0,685 | 0,628 | 0,6 | 0,577 |
| **Note** Intermediate values to be obtained by linear interpolation | | | | | | |

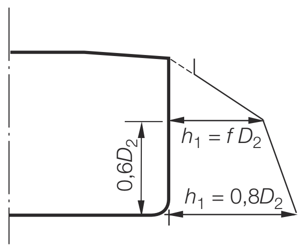



**Figure 4.7.4 Load height diagram for framing members**

7.11.8 The effective cross-sectional area $A_1$ of the collar arrangements is to be taken as the sum of cross-sectional areas of the components of the connection as follows:

(a) Direct connection:

$$A_1 = 0,01 b_1 t_w \text{ cm}^2$$

(b) Lug connection:

$$A_1 = 0,01 f_1 b_1 t_1 \text{ cm}^2$$

where

$f_1$ = 1,0 for symmetrical secondary member connections

= $\dfrac{140}{W_1}$

$t_w$ = thickness of primary member web, in mm

$t_l$ = thickness, in mm, of lug connection, and is to be taken not greater than the thickness of the adjacent primary member web plate

$W$ = overall width of the cut-out, in mm

$W_l$ = width for cut-out asymmetrical to secondary member web, in mm

*See Figure 4.7.5 Cut-outs and connections*

7.11.9 The values of $A_f$ and $A_1$ are to be such that the stresses given in *Table 4.7.11 Permissible stresses* are not exceeded.

7.11.10 Where a bracket is fitted to the primary member web plate in addition to a connected stiffener, it is to be arranged on the opposite side to, and in alignment with the stiffener. The arm length of the bracket is to be not less than the depth of the stiffener, and its cross-sectional area through the throat of the bracket is to be included in the calculation of $A_f$.

7.11.11 In general where the primary member stiffener is connected to the secondary member, it is to be aligned with the web of the secondary member, except where the face plate of the latter is offset and abutted to the web, in which case the stiffener connection is to be lapped. Lapped connections of primary member stiffeners to mild steel bulb plate or rolled angle secondary members may also be permitted. Where such lapped connections are fitted, particular care is to be taken to ensure that the primary member stiffener wrap around weld connection is free from undercut and notches, *see also Pt 3, Ch 4, 7.7 Inspection of welds*.

7.11.12 Fabricated longitudinals having the face plate welded to the underside of the web, leaving the edge of the web exposed, are not recommended for side shell and longitudinal bulkhead longitudinals. Where it is proposed to fit such sections, a symmetrical arrangement of connection to transverse members is to be incorporated. This can be achieved by fitting backing brackets on the opposite side of the transverse web or bulkhead. The primary member stiffener and backing brackets are to be lapped to the longitudinal web, *see Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.11*.

7.11.13 Collar arrangements are to satisfy the requirements of *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.1* to *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.12* inclusive. In addition, the weld area of the connections is to be not less than the following:

(a) Connection of primary member stiffener to the secondary member:

$A_w$ = 0,25$A_f$ or 6,5 cm$^2$ whichever is the greater, corresponding to a weld factor of 0,34 for the throat thickness

(b) Connection of secondary member to the web of the primary member:

$A_w = 0,5\sqrt{Z}$ corresponding to a weld factor of 0,34 in tanks or 0,27 in dry spaces for the throat thickness

where

$A_w$ = weld area, in cm$^2$, and is calculated as total length of weld, in cm, multiplied by throat thickness, in cm

$A_f$ = cross-sectional area of the primary member web stiffener, in cm$^2$, in way of connection

Z = the section modulus, in cm$^3$, of the secondary member.

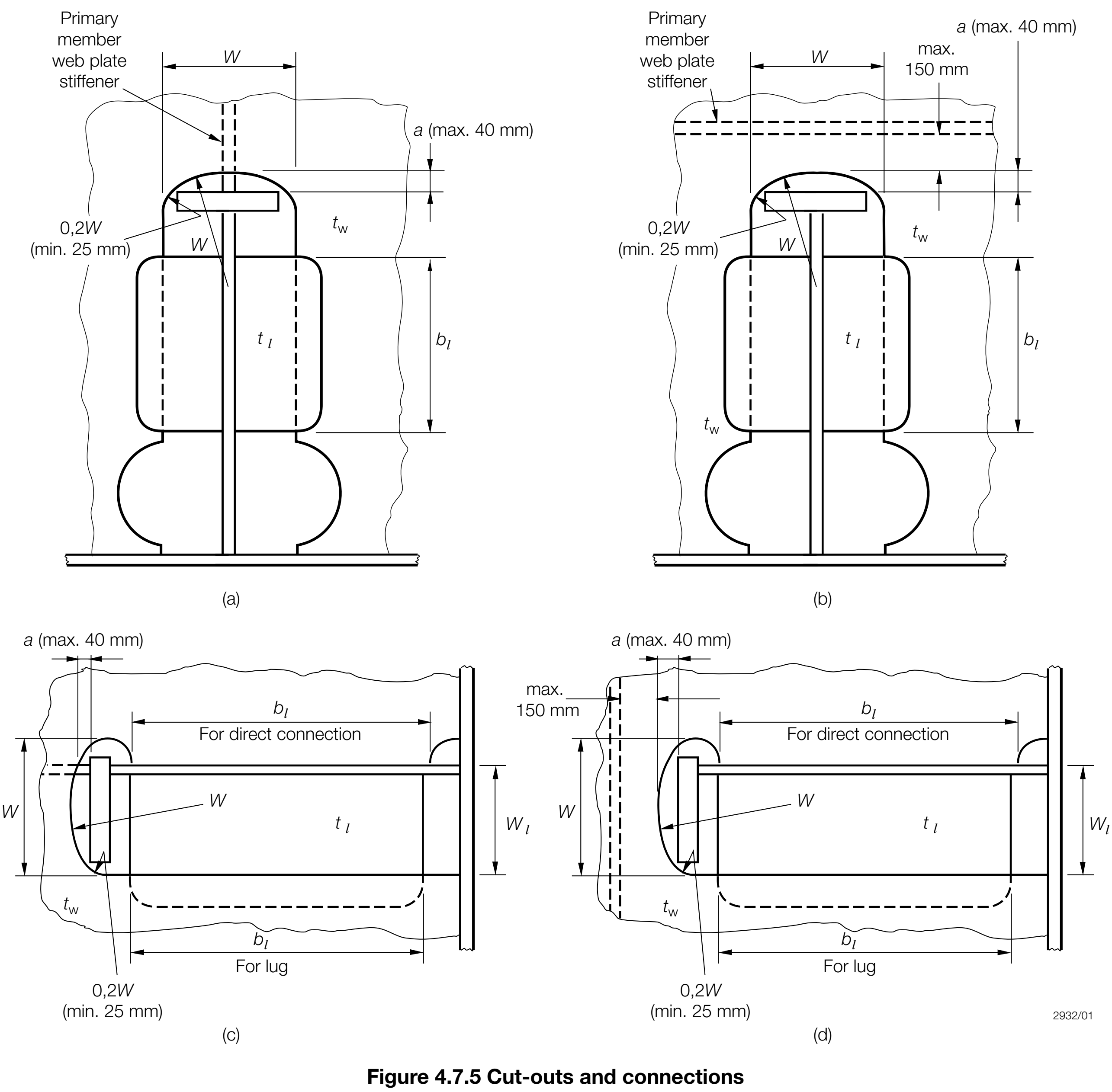



**Figure 4.7.5 Cut-outs and connections**

**Table 4.7.11 Permissible stresses**

| Item | | Direct stress, in N/mm$^2$ (*see* Notes 1 and 2) | Shear stress, in N/mm$^2$ (*see* Notes 1 and 2) |
| --- | --- | --- | --- |
| Primary member web plate stiffener within distance *a* of end, *see Figure 4.7.5 Cut-outs and connections*. | | 157 | - |
| Welding of primary member web plate stiffener to secondary member | Butted | 117,7 (double continuous fillet) | - |
| | | 157 (automatic deep penetration) | - |
| | Lapped | - | 98,1 *See* Note 2 |
| Lug or collar plate and weld | Single | - | 98,1 |
| | Double | | |
| Note 1. The welding requirements of *Pt 3, Ch 4, 7.1 Application* to *Pt 3, Ch 4, 7.7 Inspection of welds* and *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.13* are also to be complied with. | | | |
| Note 2. Where longitudinals are of higher tensile steel having a yield stress of 315 N/mm$^2$ or more, these stresses are to be divided by the factor 1,2 for application to side longitudinals above $0,3D^2$ from the base line. For definition of $D_2$ *see Table 4.7.9 Total load transmitted to connection of secondary members*. | | | |

7.11.14 Where the stiffeners of the double bottom floors, and the hopper primary members are unconnected to the secondary members and offset from them (*see Figure 4.7.6 Arrangement with offset stiffener*), the collar arrangement is to satisfy the requirements of *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.1* to *Pt 3, Ch 4, 7.11 Arrangements at intersections of continuous secondary and primary members 7.11.13* inclusive. In addition, the fillet welds attaching the lugs to the secondary members are to be based on a weld factor of 0,44 for the throat thickness. To facilitate access for welding the offset stiffeners are to be located 50 mm from the slot edge furthest from the web of the secondary member. The ends of the offset stiffeners are to be suitably tapered and softened.

7.11.15 Alternative arrangements will be considered on the basis of their ability to transmit load with equivalent effectiveness. Details of the calculations made and testing procedures are to be submitted.

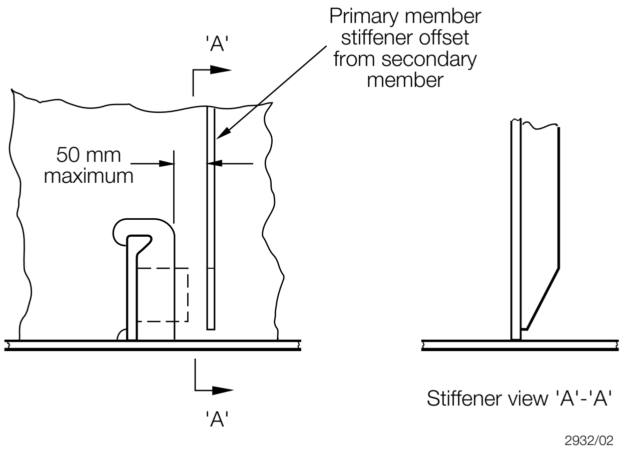



**Figure 4.7.6 Arrangement with offset stiffener**

### 7.12 Openings

7.12.1 Manholes, lightening holes and other cut-outs are to be avoided in way of concentrated loads and areas of high shear. In particular, manholes and similar openings are not to be cut in vertical or horizontal diaphragm plates in narrow cofferdams or double plate bulkheads within one-third of their length from either end, nor in floors or double bottom girders close to their span

ends, or below the heels of pillars, unless the stresses in the plating and the panel buckling characteristics have been calculated and found satisfactory.

7.12.2 Manholes, lightening holes and other openings are to be suitably framed and stiffened where necessary.

7.12.3 Air and drain holes, notches and scallops are to be kept at least 200 mm clear of the toes of end brackets and other areas of high stress. Openings are to be well rounded with smooth edges. Details of scalloped construction are shown in *Figure 4.7.1 Weld dimensions and types*. Closely spaced scallops are not permitted in higher tensile steel members. Widely spaced air or drain holes may be accepted, provided that they are of elliptical shape, or equivalent, to minimise stress concentration and are, in general, cut clear of the weld connection.

### 7.13 Sheerstrake

7.13.1 Where an angled gunwale is fitted, the top edge of the sheerstrake is to be kept free of all notches and isolated welded fittings.

7.13.2 Where a rounded gunwale is adopted, the welding of fairlead stools and other fittings to this plate is to be kept to the minimum, and the design of the fittings is to be such as to minimise stress concentration.

7.13.3 Arrangements are to ensure a smooth transition from rounded gunwale to angled gunwale towards the ends of the ship.

### 7.14 Fittings and attachments

7.14.1 The quality of welding and general workmanship of fittings and attachments are to be equivalent to that of the main hull structure. Visual examination of all welds is to be supplemented by non-destructive testing as considered necessary by the Surveyor.

7.14.2 Gutterway bars at the upper deck are to be so arranged that the effect of main hull stresses on them is minimised.

7.14.3 Minor attachments, such as pipe clips, staging lugs and supports, are generally to be kept clear of toes of end brackets, corners of openings and similar areas of high stress. Where connected to asymmetrical stiffeners, the attachments may be in line with the web providing the fillet weld leg length is clear of the offset face plate or flange edge. Where this cannot be achieved the attachments are to be connected to the web, and in the case of flanged stiffeners they are to be kept at least 25 mm clear of the flange edge. On symmetrical stiffeners, they may be connected to the web or to the centreline of the face plate in line with the web.

7.14.4 Where necessary in the construction of the ship, lifting lugs can be welded to the hull plating but they are not to be slotted through. Where they are subsequently removed, this is to be done by flame or mechanical cutting close to the plate surface, and the remaining material and welding ground off. After removal the area is to be carefully examined to ensure freedom from cracks or other defects in the plate surface.

## ■ *Section 1* General

### 1.1 Application

1.1.1 This Chapter provides the strength requirements for bridges and ramps, used for the carriage of vehicles between ship and shore, and their support structures.

1.1.2 The bridges and ramps may span between:

(a) The quay-side and a pontoon.
(b) The quay-side and a non-buoyant means of support (e.g. gantry).
(c) A pontoon and the berthed ship.
(d) The quay-side and the berthed ship, or,

may be entirely supported by a pontoon or two non-buoyant supports.

### 1.2 Objective

1.2.1 The scantlings and supporting arrangements are to be consistent with the method of support, the environmental conditions prevailing at the operating location, the berthing conditions and the specified vehicle loading data.

1.2.2 Bridges, ramps and their bearings are to be suitably designed to accommodate, where applicable, the effects of a static support at one end and a dynamic support at the other.

1.2.3 Consideration is to be given to the proposed frequency of use, including the frequency of ferry berthings and the number of vehicles using the bridges and ramps.

### 1.3 Basis of structural design

1.3.1 The adequacy of the structural components in this chapter is assessed on the basis of an allowable stress and factored load approach.

### 1.4 Information required for approval

1.4.1 See general note on Information to be submitted for approval in *Pt 3, Ch 1, 8 Information required for approval*.

## ■ *Section 2* Materials

### 2.1 General requirements

2.1.1 The materials used in the construction of bridges and ramps, including their support and restraint arrangements and any movable extensions, are to comply where applicable, with the requirements of *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

## Section 3
## Design loads and combinations

### 3.1 General

3.1.1 When loaded, all bridges and ramps are to be considered for the worst possible in-service combination of loads, inclinations, and support arrangements arising from the following forces:

(a) Self-weight.
(b) Applied vehicle loadings.
(c) Dynamic forces due to vehicle movement including braking, skidding and cornering effects.
(d) Static and dynamic forces due to inclination, twist and movement of the pontoon or other buoyant support.
(e) Operational environmental loads (e.g. wind, wave and current), including those acting on a berthed ship which can be transferred to the linkspan structure.
(f) Forces transferred to the linkspan due to motions of the berthed ship.

3.1.2 When unloaded and out-of-service all bridges and ramps are to be considered for the worst possible combination of loads, angles and support arrangements arising from the following forces:

(a) Self-weight.
(b) Static and dynamic forces due to inclination and movement of the pontoon or other buoyant support.
(c) Extreme environmental loads (e.g. wind, wave and current) appropriate to the location.

3.1.3 For raising or slewing manoeuvres the bridges and ramps are to be considered with respect to the following forces:

(a) Self-weight.
(b) Dynamic forces due to hoisting/slewing.
(c) Static and dynamic forces due to inclination and movement of the pontoon or other buoyant support.
(d) Environmental loads.
(e) Loads due to ship motions transmitted through any ship to linkspan connection, as appropriate.

### 3.2 Basic load factors

3.2.1 The self-weight load, $L_w$, is to be taken as the weight of the ramp or bridge for all design conditions, except when it is being mechanically raised or lowered, in which case it is to be multiplied by a dynamic factor of 1,1.

3.2.2 The applied load, $L_c$, is the static load on the ramp or bridge due to vehicles and is to be multiplied by a factor of 1,1 to take account of vehicle movement.

3.2.3 Environmental loads, $L_e$, need not be multiplied by any factor.

3.2.4 HA and HB vehicle loading already contain an allowance for impact and need not be further factored.

### 3.3 Forces due to motion of the pontoon or other buoyant support

3.3.1 Ramps and bridges are to be designed to operate safely and efficiently when accommodating any inclination or dynamic movement of the pontoon or other buoyant structure from which they derive their support.

### 3.4 Load combinations

3.4.1 Ramps and bridges are to be considered for the design loadings resulting from the following load cases:

(a) Case 1: Loaded operational in-service condition.
(b) Case 2: Unloaded, out of service, survival condition.
(c) Case 3: Manoeuvring condition when unloaded (if appropriate), i.e. when being mechanically hoisted or lowered.

**Case 1.** The bridge or ramp is to be considered with respect to self weight plus the applied load multiplied by 1,1, together with any horizontal, vertical and rotational forces resulting from pontoon movement and slope of the bridge/ramp, together with any loads imposed by the ship and any environmental loading. This is represented by the following expression:

$$L_w + 1,1 L_{vV} + L_{vp} + L_{hp} + L_{rp} + L_{vH} + L_e + L_{sr} + L_s$$

where the above loads are added vectorially, and where:

$L_{w}$ = self weight load

$L_{vV}$ = applied vehicular load normal to deck

$L_{vp}$ = vertical force from pontoon movement

$L_{hp}$ = horizontal force from pontoon movement

$L_{rp}$ = rotational forces from pontoon movement

$L_{vH}$ = load due to slope of bridge/ramp including braking or skidding loads

$L_{e}$ = environmental loads as appropriate

$L_{sr}$ = load from ship's ramp

$L_{s}$ = loads due to ship movement transmitted through any ship to linkspan connection

**Case 2.** The bridge or ramp is to be considered with respect to the direct forces resulting from the extreme environmental conditions (generally 1 in 50 year return case) and from the corresponding forces acting on the self weight resulting from the accelerations due to pontoon motions and static inclination resulting from the same severe environmental conditions.

**Case 3.** The bridge or ramp is to be considered with respect to its self weight multiplied by 1,1 together with any additional vertical, horizontal and rotational forces resulting from pontoon motions, *see Pt 3, Ch 5, 3.3 Forces due to motion of the pontoon or other buoyant support 3.3.1*.

For ramps which are unloaded during manoeuvring this is represented by the following expression:

$$1,1L_w + L_{vp} + L_{hp} + L_{rp}$$

where the above loads are added vectorially.

## ■ Section 4
## Design criteria

### 4.1 Allowable stress - Elastic failure

4.1.1 The allowable stress, $\sigma_a$, is to be taken as the failure stress of the component concerned multiplied by a stress factor, *F*, which depends on the load case considered. The allowable stress is given by the general expression:

$$\sigma_a = F\sigma \text{ or } \tau_a = F\tau$$

where

$\sigma_a$ = allowable direct stress, in N/mm$^2$

$\tau_a$ = allowable shear stress, in N/mm$^2$

$F$ = stress factor

$\sigma$, $\tau$ = failure stress, in N/mm2.

4.1.2 The stress factors, F, for steels in which $\dfrac{\sigma_y}{\sigma_u} \le 0,7$

where

$\sigma_y$ = yield stress of material, in N/mm$^2$

$\sigma_u$ = ultimate tensile stress of the material, in N/mm$^2$

are given in *Table 5.4.1 Stress factor, F*.

**Table 5.4.1 Stress factor, F**

| Load Case | 1 | 2 | 3 |
|---|---|---|---|
| Stress factor, *F* | 0,60 | 0,85 | 0,6 |

4.1.3 For steel with $\frac{\sigma_y}{\sigma_u} > 0,7$ the allowable stress is to be derived from the following expression:

$$\sigma_a = 0{,}41F(\sigma_u + \sigma_y)$$

$$\tau_a = 0{,}24F(\sigma_u + \sigma_y)$$

where

= $\sigma_a$ and $\tau_a$ are defined in *Pt 3, Ch 5, 4.1 Allowable stress - Elastic failure 4.1.1*.

4.1.4 The failure stress for the elastic modes of failure are given in *Table 5.4.2 Failure stress*.

**Table 5.4.2 Failure stress**

| Mode of failure | Symbol | Failure stress |
|---|---|---|
| Tension | $\sigma_t$ | $1{,}0\sigma_y$ |
| Compression | $\sigma_c$ | $1{,}0\sigma_{cr}$ |
| Shear | $\tau$ | $0{,}58\sigma_y$ |
| Bearing | $\sigma_{br}$ | $1{,}0\sigma_y$ |

4.1.5 For components subjected to combined stresses the following allowable stress criteria are to be used:

(a) $\sigma_{xx} < F\sigma_t$
(b) $\sigma_{yy} < F\sigma_t$
(c) $\tau_o < F\tau$
(d) $\sigma = (\sigma_{xx}{}^2 + \sigma_{yy}{}^2 - \sigma_{xx}\sigma_{yy} + 3\tau_o{}^2)^{1/2} \leq 1{,}1F\sigma_t$

where

$\sigma_{xx}$ = applied stress in x direction, in N/mm$^2$

$\sigma_{yy}$ = applied stress in y direction, in N/mm$^2$

$\tau_o$ = applied shear stress, in N/mm$^2$.

### 4.2 Allowable stress - Compression and bending members

4.2.1 The allowable axial stress for compression members is to be taken as the critical compressive stress, $\sigma_{cr}$, multiplied by the allowable stress factor, *F*, as defined in *Table 5.4.1 Stress factor, F*.

4.2.2 For members subjected to simple compression the critical compression stress is given by the Perry-Robertson formula below:

$$\sigma_{cr} = \frac{\sigma_y + (1+\eta)\sigma_e}{2} - \sqrt{\left(\frac{\sigma_y + (1+\eta)\sigma_e}{2}\right)^2 - \left(\sigma_e - \sigma_y\right)}$$

where

$$\sigma_e = \frac{\pi^2 E}{\left(\frac{Kl}{r}\right)^2}$$

where

$\eta$ = $0,001a\left(\frac{Kl}{r} - 0,2\,\pi\sqrt{\frac{E}{\sigma_y}}\right)$

$E$ = Young's modulus, in N/mm$^2$

$l$ = length in mm

$r$ = radius of gyration, in mm

$a$ = Robertson's constant as per *Table 5.4.3 Values of Robertson Constant, a, for various sections*

$\sigma_y$ = yield stress, in N/mm$^2$

$K$ = constant dependant on the end constraint condition of the member as per *Table 5.4.4 Value K, for different constraint conditions*.

4.2.3 For members subjected to combined bending and compression the following stress criteria are to be used:

$$\frac{\sigma_{bx} + \sigma_{by}}{\sigma_t} + \frac{\sigma_c}{\sigma_{cr}} < F$$

where

$\sigma_{bx}$ = applied bending stress about the X-X axis, in N/mm$^2$

$\sigma_c$ = applied compression stress, in N/mm$^2$

$\sigma_{by}$ = applied bending stress about the Y-Y axis, in N/mm$^2$.

### 4.3 Allowable stress - Plate buckling failure

4.3.1 The allowable stress is to be taken as the critical buckling stress $\sigma_{cb}$, $\sigma_{bb}$, or $\tau_b$ as appropriate of the component concerned multiplied by the stress factor, *F*, as defined in *Table 5.4.1 Stress factor, F*.

4.3.2 For components subject to compression the critical buckling stress is given by:

(a) for $\sigma_{cb} < 0,5\sigma_y$

$$\sigma_{cb} = K_c E \left(\frac{t}{b}\right)^2$$

(b) for $\sigma_{cb} \geq 0,5\sigma_y$

$$\sigma_{cb} = \sigma_y\left(1 - \frac{\sigma_y}{4K_c E\left(\frac{t}{b}\right)^2}\right)$$

where

$\sigma_{cb}$ = critical compression buckling stress, in N/mm$^2$

$\sigma_y$ = yield stress, in N/mm$^2$

$E$ = Young's modulus, in N/mm$^2$

$t$ = plate thickness, in mm

$b$ = plate width, i.e. normal to direction of stress, in mm.

$K_c$ = compression buckling constant, defined as follows

for $\alpha \geq 1$:

$$K_c = \frac{\pi^2}{12\left(1 - \mu^2\right)}\frac{8,4}{2,1} = 3,615$$

for $\alpha < 1$:

$$K_c = \frac{\pi^2}{12\left(1 - \mu^2\right)}\left(\alpha + \frac{1}{\alpha}\right)^2$$

where

$\alpha = \frac{a}{b}$

$\mu$ = Poisson’s ratio

$a$ = plate length, i.e. in the direction of stress

The graphical representation of $K_c$ is provided in *Figure 5.4.1 Compression buckling constant Kc*.

= $\frac{a}{b}$

= Poisson’s ratio

= plate length, i.e. in the direction of stress

4.3.3 For components subject to shear, the critical buckling stress is given by:

(a) for $\tau_b < 0,29\sigma_y$

$$\tau_b = K_s E \left(\frac{t}{b}\right)^2$$

(b) for $\tau_b \geq 0,29\sigma_y$

$$\tau_b = 0,58\sigma_y \left(1 - \frac{0,58\sigma_y}{4K_s E\left(\frac{t}{b}\right)^2}\right)$$

where

$\tau_b$ = critical shear buckling stress, in N/mm$^2$

$\sigma_y$ = yield stress, in N/mm$^2$

$E$ = Young's modulus, in N/mm$^2$

$t$ = plate thickness, in mm

$b$ = smallest plate dimension, in mm.

$K_s$ = shear buckling constant, defined as follows

for $\alpha \geq 1$:

$$K_s = \frac{\pi^2}{12\left(1 - \mu^2\right)}\frac{8,4}{2,1} = 3,615$$

for $\alpha < 1$:

$$K_s = \frac{\pi^2}{12\left(1 - \mu^2\right)}\left(4,0 + \frac{534}{\alpha^2}\right)$$

where

$\alpha = \frac{a}{b}$

$\mu$ = Poisson’s ratio

$a$ = plate length corresponding to $b$

where

The graphical representation of $K_s$ is provided in *Figure 5.4.2 Shear buckling constant Ks*.

= $\frac{a}{b}$

= Poisson's ratio

= plate length corresponding to *b*

4.3.4 For components subject to bending stress the critical buckling stress is given by:

(a) for $\sigma_{bb} < 0{,}5\sigma_y$

$$\sigma_{bb} = K_b E \left(\frac{t}{b}\right)^2$$

(b) for $\sigma_{bb} \geq 0{,}5\sigma_y$

$$\sigma_{bb} = \sigma_y \left(1 - \frac{\sigma_y}{4K_b E\left(\frac{t}{b}\right)^2}\right)$$

where

$\sigma_{bb}$ = critical buckling stress, in N/mm$^2$

$\sigma_y$ = yield stress, in N/mm$^2$

$E$ = Young's modulus, in N/mm$^2$

$t$ = plate thickness, in mm

$b$ = plate width, i.e. normal to direction of stress, in mm.

$K_b$ = bending buckling constant, defined as follows

for $\alpha \geq \frac{2}{3}$ :

$$K_b = \frac{\pi^2}{12\left(1 - \mu^2\right)} 23{,}9 = 21{,}6$$

for $\alpha < \frac{2}{3}$:

$$K_b = \frac{\pi^2}{12\left(1 - \mu^2\right)} \left(15{,}87 + \frac{1{,}87}{\alpha^2} + 8{,}6\alpha^2\right)$$

where

$\alpha$ = $\frac{a}{b}$

$\mu$ = Poisson's ratio

$a$ = plate length, i.e. in the direction of stress

The graphical representation of $K_b$ is provided in *Figure 5.4.3 Bending buckling constant Kb*.

= $\frac{a}{b}$

= Poisson's ratio

= plate length, i.e. in the direction of stress

4.3.5 For components subject to combined compression and shear, the following allowable stress criteria are to be met:

(a) $\sigma_c < F\sigma_{cb}$

(b) $\tau < F\tau_b$

(c) $$\frac{\sigma_c}{\sigma_{cb}} + \left(\frac{\tau}{\tau_b}\right)^2 < F$$

$\tau$ = applied shear stress, in N/mm$^2$.

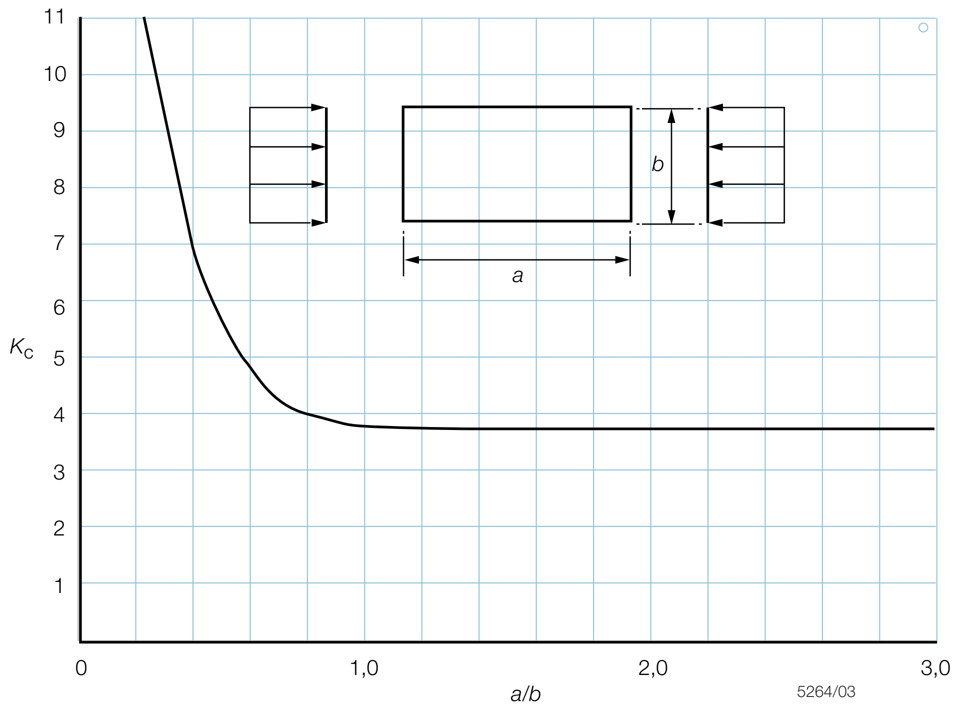



**Figure 5.4.1 Compression buckling constant Kc**

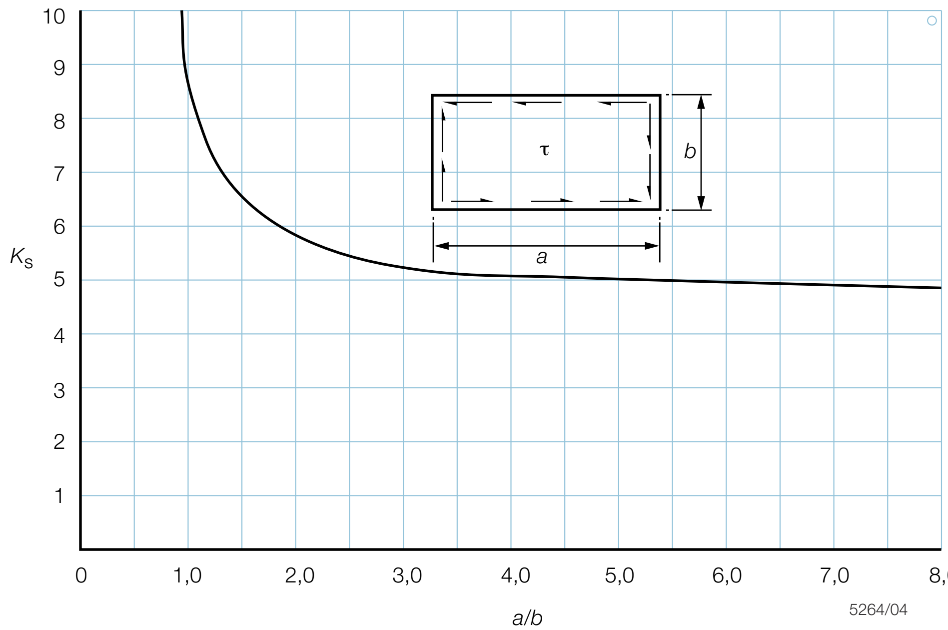



**Figure 5.4.2 Shear buckling constant Ks**

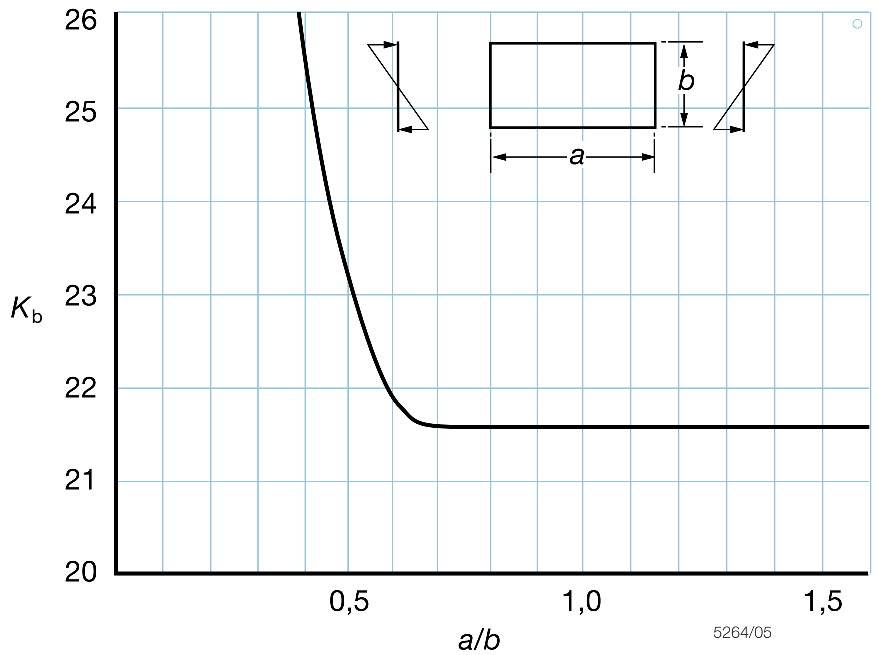



**Figure 5.4.3 Bending buckling constant Kb**

4.3.6 For components subject to combined bending and shear, the following stress criteria are to be met:

(a) $\sigma_b < F\sigma_{bb}$

(b) $\tau < F\tau_b$

(c) $\left(\frac{\sigma_b}{\sigma_{bb}}\right)^2 + \left(\frac{\tau}{\tau_b}\right)^2 < F$

**Table 5.4.3 Values of Robertson Constant, a, for various sections**

| Type of section | Thickness of flange or plate, in mm | Axis of buckling | *a* |
| --- | --- | --- | --- |
| Rolled section (universal beams) | | xx | 2,0 |
| Roled H section (universal columns | up to 40 | xx | 3,5 |
| *See* Note 1 | | yy | 5,5 |
| | over 40 | xx | 5,5 |
| | | yy | 8,0 |
| Welded plate or H sections | up to 40 | xx | 3,5 |
| *See* Notes 1, 2 and 3 | | yy | 5,5 |
| | over 40 | xx | 3,5 |
| | | yy | 8,0 |
| Rolled or H section with welded flange cover plates | | xx | 3,5 |
| *See* Notes 1 and 4 | | yy | |
| | | xx | 2,0 |
| | | yy | |
| Welded box sections | up to 40 | any | 3,5 |
| *See* Note 1, 3 and 4 | over 40 | any | 5,5 |
| Rolled channel sections, rolled angle sections and T-bars (rolled or cut from universal beam or column) | | any | 5,5 |
| Hot-rolled structural hollow sections | | any | 2,0 |
| Rounds, square and flat bars | up to 40 | any | 3,5 |
| *See* Note 1 | Over 40 | any | 5,5 |
| Compound rolled sections (2 or more , H or channel sections, section plus channel, etc.) | | any | 5,5 |
| Two rolled angle, channel or T-sections, back to back | | any | 5,5 |
| Two rolled sections laced or battened | | any | 5,5 |
| Lattice strut | | any | 2,0 |

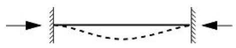
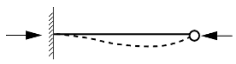
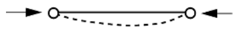
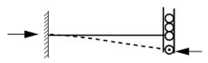
Note 1. For thickness between 40 mm and 50 mm the value $\sigma cb$, $\tau b$ or $\sigma bb$ may be taken as the average of the value for thicknesses less than 40 mm and the value for thicknesses greater than 40 mm.

Note 2. For welded plate or H sections where it can be guaranteed that the edges of the flanges will only be flame-cut, *a* = 3,5 may be used for buckling about the y-y axis for flanges up to 40 mm thick and , *a* = 5,5 for flanges over 40 mm thick.

Note 3. Yield strength for sections fabricated from plate by welding reduced by 25 N/mm*2*.

Note 4. `Welded box sections' include those fabricated from four plates, two angles or an or H section and two plates but not box sections composed of two channels or plates with welded logitudinals stiffeners.

**Table 5.4.4 Value K, for different constraint conditions**

| Diagramatic representation | Restraint conditions | *K* |
|---|---|---|
|  | Constrained against rotation and translation at both ends | 0,7 |
|  | Constrained against rotation and translation at one end and translation only at other end | 0,85 |
|  | Constrained against translation only at each end | 1,0 |
|  | Constrained against rotation and translation at one end and against rotation only at other end | 1,5 |
|  | Constrained against rotation and translation at one end and free to rotate and translate at other end | 2,0 |

4.3.7 For components subject to combined bending and compression the following allowable stress criteria are to be met:

(a) $\sigma_c < F\sigma_{cb}$

(b) $\sigma_b < F\sigma_{bb}$

(c) $\left(\frac{\sigma_c}{\sigma_{cb}}\right)^2 + \left(\frac{\sigma_b}{\sigma_{bb}}\right)^2 < F$

4.3.8 For components subject to combined compression, bending and shear, the following allowable stress criteria are to be met:

(a) $\sigma_c < F\sigma_{cb}$

(b) $\sigma_b < F\sigma_{bb}$

(c) $\tau < F\tau_b$

(d) $\left(\frac{\tau}{\tau_b}\right)^2 + \left(\frac{\sigma_c}{\sigma_{cb}}\right) + \left(\frac{\sigma_b}{\sigma_{bb}}\right)^2 < F$

## 4.4 Allowable stress - Joints and connections

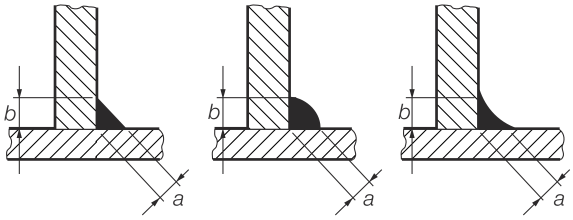
4.4.1 For welded joints, the physical properties of the weld metal are considered as equal to the parent metal. For full penetration butt welds, the allowable stress is equal to the allowable stress of the parent material (*see Pt 3, Ch 5, 4.1 Allowable stress - Elastic failure*).

4.4.2 For fillet welds and welds subjected to shear, the allowable stresses are reduced. Values of these reduced stresses are given in *Table 5.4.5 Allowable stresses in welds, N/mm2*. Where, *F*, is the stress factor, *see Table 5.4.1 Stress factor, F*.

**Table 5.4.5 Allowable stresses in welds, N/mm2**

| Type of weld | Allowable stress | |
|---|---|---|
| | Direct | Shear |
| Full penetration butt weld | 1,0 $F\sigma_y$ | 0,58 $F\sigma_y$ |
| Fillet welds | 0,7 $F\sigma_y$ | 0,58 $F\sigma_y$ |

4.4.3 The design stress in fillet welds is to be calculated on the `throat' dimension of the weld. *See Figure 5.4.4 Fillet weld dimensions*.




*b* = the leg length
*a* = the design throat thickness

**Figure 5.4.4 Fillet weld dimensions**

4.4.4 The strength of joints using pretensioned bolts to transmit shear and/or tensile forces, e.g. high strength friction grip bolts, is to be determined in accordance with an appropriate National or other acceptable code or standard.

4.4.5 For joints using precision bolts, defined as turned or cold finished bolts fitted into drilled or reamed holes whose diameter is not greater than the bolt diameter by more than 0,4 mm, the allowable stress due to the externally applied load is given in *Table 5.4.6 Allowable stresses for fitted bolts*.

4.4.6 Where joints are subjected to fluctuating or reversal of load across the joint the bolts are to be pretensioned by controlled means to between 70 and 80 per cent of their specified yield stress.

**Table 5.4.6 Allowable stresses for fitted bolts**

| Type of loading | Allowable stress | |
|---|---|---|
| | Load cases 1 and 3 | Load case 2 |
| Tension | 0,4 $\sigma_y$ | 0,54 $\sigma_y$ |
| Single shear | 0,38 $\sigma_y$ | 0,51 $\sigma_y$ |
| Double shear | 0,57 $\sigma_y$ | 0,77 $\sigma_y$ |
| Tension and shear | 0,48 $\sigma_y$ | 0,64 $\sigma_y$ |
| $\left(\sigma_t^2 + 3\tau^2\right)^{\frac{1}{2}}$ | | |
| Bearing | 0,9 $\sigma_y$ | 1,2 $\sigma_y$ |

4.4.7 Black bolts (ordinary grade bolts) are not to be used for primary joints or joints subject to fatigue.

### 4.5 Deck plating thickness

4.5.1 The deck plating thickness, *t*, for bridges and ramps is to be adequate for the intended vehicle traffic and is to be calculated with reference to the method described in *Pt 3, Ch 4, 3.3 Deck plating*.

4.5.2 In addition to accommodating the local tyre print loads, the deck plating may also contribute to the overall strength of the bridge or ramp and therefore is to satisfy the allowable stress criteria of *Pt 3, Ch 5, 4.1 Allowable stress - Elastic failure* and the plate buckling requirements in *Pt 3, Ch 5, 4.3 Allowable stress - Plate buckling failure*.

### 4.6 Deflection criteria

4.6.1 In Case 1 the deflection of the bridge or ramp between supports under the applied load is to be limited to that given by the following expression:

$$\frac{L}{400}\ \mathrm{mm}$$

where

$L$ = distance between supports, in mm.

4.6.2 For cantilevered sections of bridges and ramps the deflection is to be limited to $\frac{L}{200}$ mm

where

$L$ = is the length of the cantilevered section.

### 4.7 Hoisting and slewing arrangements

4.7.1 Where chains are used as part of the hoisting or slewing arrangement they are to have a minimum safety factor of 4,0.

4.7.2 Where wire ropes are used as part of the hoisting or slewing arrangement the safety factor is to be determined as:

$$SF = \frac{10^4}{8,85W + 1910}$$

where

$SF$ = minimum safety factor required

$W$ = weight of the ramp in tonnes (for ramps which are unloaded during manoeuvring)

The actual design safety factor is to be not less than four and need not be greater than five.

### 4.8 Locking arrangements

4.8.1 Where bridges and ramps are raised or lowered in the unloaded condition and then pinned or locked off to support both the dead weight and vehicle loads, the pins (or locking device) are to be adequate for the worst loading derived from Case 1 and are to satisfy the allowable stress criteria of *Pt 3, Ch 5, 4.1 Allowable stress - Elastic failure*,*Pt 3, Ch 5, 4.2 Allowable stress - Compression and bending members* ,*Pt 3, Ch 5, 4.3 Allowable stress - Plate buckling failure* ,*Pt 3, Ch 5, 4.4 Allowable stress - Joints and connections*.

### 4.9 Safety restraints

4.9.1 Where a bridge or ramp is retained in position by a single articulated mechanical connection a suitable means is to be provided to prevent the complete detachment of the bridge or ramp from the support in the event of failure of the joint.

4.9.2 Chains or wire ropes used for this purpose are to take due account of the kinetic energy developed by the falling structure and are to have a safety factor of at least two.

4.9.3 To prevent movement and consequent failure, pins for all primary hinges and articulations are to be locked in position by adequate keep plates, castellated and wired nuts, end cover plates or other suitable means.

### 4.10 Deck gradients and transitions

4.10.1 The gradients of bridges and ramps are in general not to exceed a slope of 1 in 10 during normal operation with ships at lowest or highest freeboard at Mean Low or High Water Spring Tides respectively. Additionally, a maximum slope of 1 in 8 will be permitted for Lowest and Highest Astronomical Tides.

4.10.2 Changes in bridge or ramp gradients and transitions are to take account of ground clearance of the vehicles using the linkspan throughout the operational range.

## ■ *Section 1* General

### 1.1 Application

1.1.1 This Chapter provides the design requirements for walkways and their support structures.

1.1.2 This Chapter is not applicable to ships' gangways, accommodation ladders, pilot ladders, or service/maintenance platforms, etc. on linkspans.

1.1.3 Walkways providing access as part of a linkspan may be an independent structure or may be integrated into the linkspan bridge or vehicle ramp. Suitable segregation of vehicular from other traffic is to be provided.

### 1.2 Objective

1.2.1 The scantlings and supporting arrangements are to be consistent with the method of support, the environmental conditions prevailing at the operating location, the berthing conditions and the specified pedestrian loading data.

1.2.2 Additionally, consideration is to be given, as appropriate, to the proposed frequency of use.

### 1.3 Information required for approval

1.3.1 *See Pt 3, Ch 1, 8 Information required for approval*.

## ■ *Section 2* Materials

### 2.1 General requirements

2.1.1 The materials used in the construction of walkways, including their support arrangements and any articulations, are to comply with the requirements of *Rules for the Manufacture, Testing and Certification of Materials, July 2020*, as appropriate.

## ■ *Section 3* Design loads and combinations

### 3.1 General

3.1.1 When loaded, walkways are to be considered for the worst possible combination of inclinations and support arrangements arising from the following forces:

(a) Self-weight.
(b) Specified loading.
(c) Static and dynamic forces due to inclination and movement of the pontoon or other buoyant support.

(d) Operational environmental loads.

(e) Loads due to ship movement transmitted to the walkway through any ship to linkspan connection.

3.1.2 When unloaded and out-of-service, walkways are to be considered for the worst possible combination of slope, twist angles and support arrangements arising from the following forces acting on the whole linkspan:

(a) Self-weight.

(b) Static and dynamic forces due to inclination and movement of the pontoon or other buoyant support.

(c) Extreme environmental loads appropriate to the location (e.g. wind, wave or current).

### 3.2 Basic load factors

3.2.1 The self-weight load, $L_w$, is to be taken as the weight of the walkway for all design conditions except when it is being mechanically raised or lowered in which case it is to be multiplied by a factor of 1,1.

3.2.2 The applied load, $L_c$, is the load on the walkway from passengers. This is usually expressed as a UDL and need not be increased by a dynamic factor as sufficient allowance has been incorporated for the effects of pedestrian movement, unless otherwise stated.

3.2.3 Environmental loads, $L_e$, need not be increased by any factor.

### 3.3 Forces due to motion of the pontoon or other buoyant support

3.3.1 Walkways are to be designed to operate safely and efficiently when accommodating any inclination or dynamic movement of the pontoon or other buoyant structure from which they derive their support.

### 3.4 Load combinations

3.4.1 Walkways are to be considered for the design loadings resulting from the following load cases:

| | | |
|---|---|---|
| (a) | Case 1: | Loaded operational in-service condition. |
| (b) | Case 2: | Unloaded, out of service, survival condition. |
| (c) | Case 3: | Manoeuvring condition when unloaded (if appropriate), i.e. when being mechanically hoisted or lowered. |

**Case 1:** The walkway is to be considered with respect to self-weight plus applied load, together with any horizontal, vertical and rotational forces resulting from pontoon movement and slope of the walkway, together with any loads imposed by the ship and any environmental loading. This is represented by the following expression:

$$L_w + L_c + L_{vp} + L_{HP} + L_{rp} + L_\theta + L_e + L_{sr} + L_s$$

where the above loads are added vectorially, and where

$L_w$ = self-weight load

$L_c$ = applied load

$L_{vp}$ = vertical force from pontoon movement

$L_{Hp}$ = horizontal force from pontoon movement

$L_{rp}$ = rotational force from pontoon movement

$L_\theta$ = load due to slope of bridge/ramp

$L_e$ = environmental forces (wind and snow and ice as appropriate)

$L_{sr}$ = load from ship's ramp

$L_s$ = loads due to ship movement transmitted through any ship to linkspan connection.

**Case 2:** The walkway is to be considered with respect to the direct forces resulting from the extreme environmental conditions (generally 1 in 50 year return case) and from the corresponding forces acting on the self-weight resulting from the accelerations due to pontoon motions and static inclination resulting from the same severe environmental conditions.

**Case 3:** The walkway is to be considered with respect to its self-weight multiplied by 1,1, together with any additional horizontal forces resulting from pontoon motions (*see Pt 3, Ch 6, 3.3 Forces due to motion of the pontoon or other buoyant support 3.3.1*), and environmental forces. This is represented by the following expression:

$$1{,}1L_w + L_{vp} + L_{Hp} + L_e$$

where the above loads are added vectorially.

## Section 4
## Design criteria

### 4.1 Allowable stresses

4.1.1 The allowable stress criteria to be used for walkways are as defined in *Pt 3, Ch 5, 4.1 Allowable stress - Elastic failure*, *Pt 3, Ch 6, 4.2 Deflection criteria*, *Pt 3, Ch 6, 4.3 Hoisting and slewing arrangements*, *Pt 3, Ch 6, 4.4 Safety restraints* inclusive.

### 4.2 Deflection criteria

4.2.1 The allowable deflection criteria for walkways is as defined in *Pt 3, Ch 5, 4.6 Deflection criteria*.

### 4.3 Hoisting and slewing arrangements

4.3.1 The safety factors for chains and steel wire ropes used for hoisting or slewing operations is as defined in *Pt 3, Ch 5, 4.7 Hoisting and slewing arrangements*.

### 4.4 Safety restraints

4.4.1 Where a bridge or ramp is retained in position by a single articulated mechanical connection, a suitable means is to be provided to prevent the complete detachment of the bridge or ramp from the support in the event of failure of the joint.

4.4.2 Chains or wire ropes used for this purpose are to take due account of the kinetic energy developed by the falling structure and are to have a safety factor of at least 2,0.

4.4.3 To prevent movement and consequent failure, pins for all primary hinges and articulations are to be locked in position by adequate keep plates, castellated and wired nuts, and cover plates or other suitable means.

## ■ *Section 1* General

### 1.1 Application

1.1.1 This Chapter is applicable to all linkspans that are either totally or partially supported by buoyant means.

1.1.2 This Chapter does not apply to linkspans that are supported by a bankseat bearing at one end and by a non-buoyant structure at the other end.

### 1.2 Scope

1.2.1 This Chapter is applicable to those aspects of mooring systems and tethering arrangements sufficient to assign the **T** class character symbol, *see Pt 1, Ch 2, 3.2 Character symbols*, to be assigned, *viz*:

(a) Mooring lines, chains, their shackles and links.
(b) Yokes and guides around piles.
(c) Permanent attachments to pontoons, bridge and ramp pontoons.
(d) Mooring booms.

1.2.2 The design and construction of the following is not covered by these Rules:

(a) Guidepiles and dolphins.
(b) Sea-bed conditions supporting guidepiles, dolphins and catenary chain anchor blocks.
(c) Quay mounted bollards.
(d) Civil engineering structures, including quays, bankseats, etc.

### 1.3 Objective

1.3.1 Each buoyant linkspan is to be secured on station by a mooring system or tethering arrangement that is able to adequately and efficiently resist environmental, operational and berthing forces applied to the linkspan.

1.3.2 The mooring system or tethering arrangement adopted is also to accommodate the full tidal range possible at the location without restricting the vertical movement of the linkspan due to the rise and fall of the tide.

## Section 2
## Materials

### 2.1 Approved manufacturers

2.1.1 All chains, ropes, cables and loose gear used for mooring systems are to be supplied from an approved manufacturer and are to have been tested in a Recognized Proving Establishment as defined in LR's *List of Approved Manufacturers and Recognized Proving Establishments*.

### 2.2 Tethering arrangements

2.2.1 The material used in any fabricated primary structural member in the tethering arrangement is to comply with *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

## Section 3
## Types of mooring and tethering arrangements

### 3.1 Mooring arrangements

3.1.1 Mooring systems generally consist of one of the following arrangements:

(a) Mooring lines and chains retaining the linkspan against a quayside or series of dolphins.
(b) A system of mooring booms keeping the linkspan at a fixed distance from the quayside.

### 3.2 Tethering arrangements

3.2.1 Tethering arrangements will generally consist of:

(a) Two or more guidepiles attached to the linkspan by a yoke (or yokes) permitting vertical movement of the linkspan but restraining horizontal movement.
(b) A single guidepile and yoke at one end of the linkspan allowing vertical tidal movement, and a bankseat arrangement allowing rotation but providing suitable translational restraint.

### 3.3 Other types

3.3.1 Other types of mooring or tethering arrangements will be considered.

3.3.2 Where the means of securing the installation is provided by frictional support from the sea bed, the pontoons are to have a factor of safety of at least 2,0 against sliding or bearing capacity failures under all loading conditions occurring at the operating location.

The available unit friction between pontoon and soil (or along any other potential failure surface, for example, between a fabric drainage mat and soil) may be required to be verified by tests. Attention is to be paid to the need to ensure good and complete contact between pontoon and soil, and to guard against possible scour from current and underbase erosion due to sub-surface erosion caused by water pressure under the base. In general, this type of securing is to be considered only for well protected locations, but each submission will be considered with respect to calculations and test data supplied by the designer.

## Section 4
## Design loads

### 4.1 Environmental loads

4.1.1 Each mooring system or tethering arrangement is to be considered with respect to the following environmental loads.

(a) Wind loading, *see Pt 3, Ch 3, 3.6 Wind loading*.

(b) Current loading, *see Pt 3, Ch 3, 3.7 Current loading*.
(c) Wave loading, *see Pt 3, Ch 3, 3.8 Wave loading*.

### 4.2 Operational loads

4.2.1 Each system is to be considered with respect to the following operational loads:

(a) Vehicle movement including braking, *see Pt 3, Ch 3, 3.4 Vehicle loads 3.4.3*.
(b) Vehicle accident or skidding, *see Pt 3, Ch 3, 3.4 Vehicle loads 3.4.3*.
(c) Forces arising from the extension/retraction of a pontoon relative to the linkspan bridge/ramp.
(d) Forces transmitted through any linkspan to ship connection.
(e) Wash from passing marine craft.

### 4.3 Berthing Loads

4.3.1 Each system is to be considered with respect to ship berthing loads as defined in *Pt 3, Ch 3, 3.9 Ship induced loadings*.

4.3.2 Where appropriate, consideration is to be given to the effects of the berthing ship's propulsion units.

## ■ *Section 5* Load combinations

### 5.1 General

5.1.1 Each mooring system and tethering arrangement is to be considered for the following design cases:

(a) Case 1 - In-service operational.
(b) Case 2 - In-service berthing.
(c) Case 3 - Out of service - severe environmental conditions.

5.1.2 **Case 1.** Each system is to be adequate for the worst combination of normal operational wind, current and wave loadings, together with one of the operational loads in *Pt 3, Ch 7, 4.2 Operational loads*. This can be represented by the following expression:

$$L_{wind.1} + L_{current.1} + L_{wave.1} + L_{operational}$$

where the above loads are added vectorially.

5.1.3 **Case 2.** Each mooring system and tethering arrangement is to be adequate for the worst combination of normal operational wind, current and wave loadings, together with the normal berthing force including the effects of the ship's propulsion units, where appropriate. This can be represented by the following expression:

$$L_{wind.1} + L_{current.1} + L_{wave.1} + L_{berthing}$$

where the above loads are added vectorially.

5.1.4 **Case 3.** Each mooring system and tethering arrangement is to be adequate for the worst combination of extreme wind, current and wave loadings together with any wash effects from passing ships, where appropriate. It is assumed that in this condition the linkspan will be out of service and no ship will be berthed or berthing. This is represented by:

$$L_{wind.2} + L_{current.2} + L_{wave.2}$$

where the above loads are added vectorially.

## Section 6
## Safety factors and allowable stresses

### 6.1 Safety factors

6.1.1 The various components of mooring systems are to have, as a minimum, the safety factors given in *Table 7.6.1 Safety factors*.

6.1.2 These safety factors assume adequate regular inspection and/or renewal. Higher safety factors may need to be considered if:

(a) The linkspan is outside protected waters (*see Pt 1, Ch 2, 1.2 Application 1.2.3*), or
(b) the in-service operational wind, wave and current loadings are likely to be frequently exceeded, or
(c) regular and adequate inspection and maintenance procedures may not be followed.

**Table 7.6.1 Safety factors**

| Component | Safety factor for normal operating conditions | Safety factor for extreme conditions |
|---|---|---|
| Chain | 3:0 | 2:0 |
| Ropes (SWR & synthetic) | 3:0 | 2:0 |
| Shackles and links | Max. load + SWL | Max. load < Proof Load |

### 6.2 Allowable stresses

6.2.1 The allowable stress criteria defined in *Pt 3, Ch 5, 4 Design criteria* will be appropriate for any fabricated components forming part of a tethering arrangement.

6.2.2 The stress factors to be used in calculating the allowable stresses for load cases 1, 2 and 3 are given in *Table 7.6.2 Stress Factor, F*.

**Table 7.6.2 Stress Factor, F**

| Load case | 1 | 2 | 3 |
|---|---|---|---|
| Stress Factor, $F$ | 0,6 | 0,6 | 0,75 |

## Section 1
## General

### 1.1 Application

1.1.1 Where it is intended, as part of normal operational procedures, for the berthing ship to make contact with a linkspan, a fendering system is to be fitted capable of absorbing the forces from ships berthing end-on or near end-on to, or alongside the, linkspan.

1.1.2 Fendering systems are to be considered for both the normal and abnormal berthing conditions defined in *Pt 3, Ch 3, 3.9 Ship induced loadings*.

1.1.3 The supporting structure or mountings for fenders are to be capable of withstanding the fender reaction forces specified in the manufacturer's performance characteristics for each fender.

1.1.4 Fenders are generally proprietary items and as such do not require to be made under survey or tested. Nevertheless, they should be supplied with appropriate certificates verifying their construction and capacity to the satisfaction of the attending Surveyor.

1.1.5 All fender units are to be installed under survey in accordance with the manufacturer's recommendations.

1.1.6 Where it is not intended, as part of normal operational procedures, for berthing ships to contact the linkspan, a statement to this effect is to be made to LR. In such circumstances a fendering system need not be fitted. However, it is recommended that this situation is made clear to all operators using the installation.

## Section 2
## Design

### 2.1 General

2.1.1 Fenders may be elastomeric, pneumatic, foam filled, or of other suitable form.

2.1.2 For limiting deflections under abnormal impact conditions, reference is to be made to the manufacturer's published performance characteristics.

2.1.3 Special consideration will be given to fenders manufactured for a specific installation.

2.1.4 Where fenders are located between the bankseat and the shore end of the linkspan, suitable rubbing strips or other means of protection are to be provided at the ship-to-linkspan contact zone.

## ■ *Section 1* Highway live loads based on BS 5400 Part 2 1978 - HA and HB

### 1.1 General

1.1.1 This Section provides guidance on how to calculate highway loading. Alternatively, highway loading is to be calculated in accordance with a recognised National or International Standard and agreed with Lloyd's Register.

1.1.2 Standard highway loading consists of HA and HB loading.

1.1.3 HA loading is a formula loading representing normal traffic in the U.K.:

- HB loading is an abnormal vehicle unit loading.
- Both loadings include an allowance for impact.

### 1.2 Type HA loading

1.2.1 Type HA loading consists of a uniformly distributed load, in kN/m$^2$, and a knife edge load, in kN/m, combined, or of a single wheel load, *see also Pt 3, Ch 9, 1.2 Type HA loading 1.2.3*.

1.2.2 **Nominal uniformly distributed load (UDL).** For loaded lengths up to and including 50 m, the UDL shall be derived from the equation:

$$\mathrm{UDL} = 336\left(\frac{1}{L}\right)^{0,67} \mathrm{kN/m}$$

where $L$ is the loaded length, in metres.

For loaded lengths in excess of 50 m, the UDL shall be derived from the equation:

$$\mathrm{UDL} = 36\left(\frac{1}{L}\right)^{0,1} \mathrm{kN/m}$$

but not less than 21,8 KN/m.

Alternatively, values for this load per linear metre of notional lane are given in *Table 9.1.1 Type HA Uniformly distributed load*.

1.2.3 **Nominal knife edge load (KEL).** The KEL per notional lane shall be taken as 120 kN.

1.2.4 **Distribution.** The UDL and KEL shall be taken to occupy one notional lane, uniformly distributed over the full width of the lane, *see Figure 9.1.1 Distribution of UDL and KEL*. The KEL is to be applied at only one point in the loaded length of the notional lane.

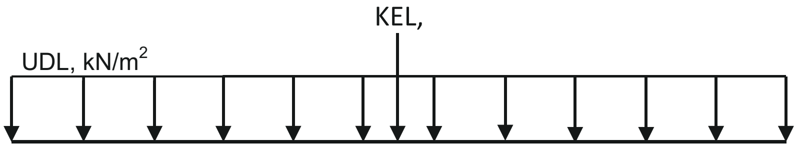



**Figure 9.1.1 Distribution of UDL and KEL**

1.2.5 **Dispersal.** No allowance for the dispersal of the UDL and KEL shall be made.

1.2.6 **Single nominal wheel load alternative to UDL and KEL.** One 100 kN wheel, placed on the carriageway and uniformly distributed over a circular contact area assuming an effective pressure of 1,1 N/mm$^2$ (i.e. 340 mm diameter), shall be considered.

Alternatively, a square contact area may be assumed, using the same effective pressure (i.e. 300 mm side).

**Table 9.1.1 Type HA Uniformly distributed load**

| Loaded length m | Load, UDL kN/m | Load length m | Load, URL kN/m |
|---|---|---|---|
| 2 | 211,2 | 44 | 26,6 |
| 4 | 132,7 | 47 | 25,5 |
| 6 | 101,2 | 50 | 24,4 |
| 8 | 83,4 | 55 | 24,1 |
| 10 | 71,8 | 60 | 23,9 |
| 12 | 63,6 | 65 | 23,7 |
| 14 | 57,3 | 70 | 23,5 |
| 16 | 52,4 | 75 | 23,4 |
| 18 | 48,5 | 80 | 23,2 |
| 20 | 45,1 | 85 | 23,1 |
| 23 | 41,1 | 90 | 23,0 |
| 26 | 37,9 | 100 | 22,7 |
| 29 | 35,2 | 110 | 22,5 |
| 32 | 33,0 | 120 | 22,3 |
| 35 | 31,0 | 130 | 22,1 |
| 38 | 29,4 | 150 | 21,8 |
| 41 | 27,9 | | |

1.2.7 **Dispersal.** Dispersal of the single nominal wheel load at a spread-to-depth ratio of one horizontally to two vertically through asphalt and similar surfacing may be assumed, where it is considered that this may take place.

Dispersal through structural concrete slabs may be taken at a spread-to-depth ratio of one horizontally to one vertically down to the neutral axis.

### 1.3 Type HB Loading

1.3.1 For all public highway bridges in Great Britain, the minimum number of units of type HB loading that shall normally be considered is 30, but this number may be increased up to 45 if so directed by the appropriate authority.

For the purposes of these Rules these figures may also apply to the bridges and ramps on a linkspan.

1.3.2 **Nominal HB loading.** *Figure 9.1.2 Dimensions of HB vehicle* shows the plan and axle arrangement for one unit of nominal HB loading. One unit shall be taken as equal to 10 kN per axle (i.e. 2,5 kN per wheel).

The overall length of the HB vehicle shall be taken as 10, 15, 20, 25 or 30 m for inner axle spacings of 6, 11, 16, 21 or 26 m respectively, and the effects of the most severe of these cases shall be adopted.

The overall width shall be taken as 3,5 m.

1.3.3 **Contact area.** Nominal HB wheel loads shall be assumed to be uniformly distributed over a circular contact area, assuming an effective pressure of 1,1 N/mm$^2$.

Alternatively, a square contact area may be assumed, using the same effective pressure.

1.3.4 **Dispersal.** Dispersal of HB wheel loads at a spread-to-depth ratio of one horizontally to two vertically through asphalt and similar surfacing may be assumed, where it is considered that this may take place.

Dispersal through structural concrete slabs may be taken at a spread-to-depth ratio of one horizontally to one vertically down to the neutral axis.

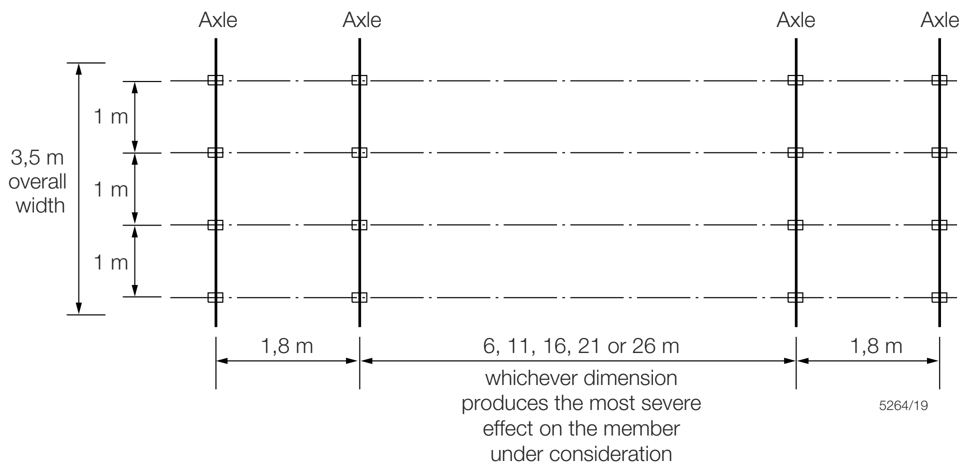



**Figure 9.1.2 Dimensions of HB vehicle**

### 1.4 Assessment of HA and HB loading

1.4.1 HA and HB loading is to be assessed in accordance with *Pt 3, Ch 5, 3.4 Load combinations* and *Pt 3, Ch 5, 4 Design criteria*. Other vehicle load combinations are to be specially considered.

## Section 2
## Aerodynamic data

### 2.1 Wind force coefficient, $C_f$

2.1.1 The force coefficient for various structural components is given in *Table 9.2.1 Force coefficient (Cf)*. The values for individual members vary according to the aerodynamic slenderness and in the case of large box sections, with the section ratio.

**Table 9.2.1 Force coefficient (Cf)**

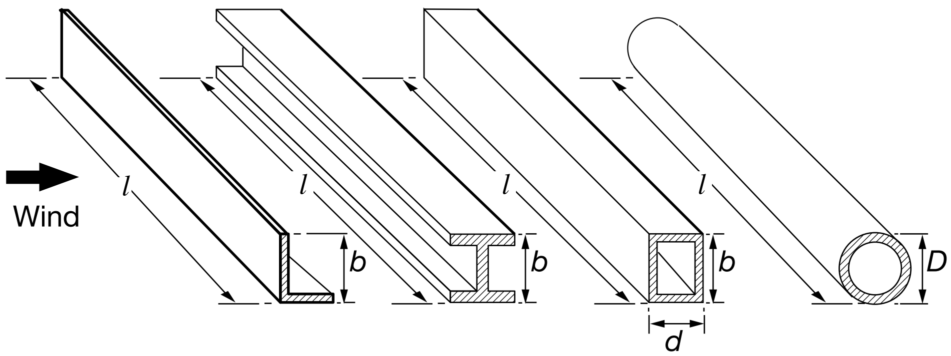
| Type | Description | | | Aerodynamic slenderness *l/b* or *l/D* | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 5 | 10 | 20 | 30 | 40 | 50 |
| | | | | Force coefficient $C_f$ | | | | | |
| Individual members | Rolled sections, rectangles, hollow sections, flat plates, box section with *b* or *d* less than 0,5m | | | 1,30 | 1,35 | 1,60 | 1,65 | 1,70 | 1,80 |
| | Circular section, where | $DV_s < 6{,}0$ m$^2$/s | | 0,75 | 0,80 | 0,90 | 0,95 | 1,00 | 1,10 |
| | | $DV_s \geq 6{,}0$ m$^2$/s | | 0,6 | 0,65 | 0,70 | 0,70 | 0,75 | 0,80 |
| | | | *b/d* | | | | | | |
| | Box section with *b* or *d* greater than 0,5 m | | ≥ 2,00 | 1,55 | 1,75 | 1,95 | 2,10 | 2,20 | |
| | | | 1,00 | 1,40 | 1,55 | 1,75 | 1,85 | 1,90 | |
| | | | 0,50 | 1,00 | 1,20 | 1,30 | 1,35 | 1,40 | |
| | | | 0,25 | 0,80 | 0,90 | 0,90 | 1,00 | 1,00 | |
| Single lattice frames | Flat sided sections | | | 1,70 | | | | | |
| | Circular section, where | $DV_s < 6{,}0$ m$^2$/s | | 1,20 | | | | | |
| | | $DV_s \geq 6{,}0$ m$^2$/s | | 0,80 | | | | | |
| Machinery houses, etc. | Rectangular clad structures on ground or solid base (air flow beneath structure prevented) | | | 1,10 | | | | | |

$D$ = the diameter of the section, in metres

$V_s$ = the design wind speed, in m/s

### 2.2 Aerodynamic slenderness and section ratio

2.2.1 The aerodynamic slenderness and section ratio are defined in *Figure 9.2.1 Aerodynamic slenderness and section ratio*.




Aerodynamic slenderness =

$$\frac{\text{length of member}}{\text{breadth of section across wind front}} = \frac{l}{b} \text{ or } \frac{l}{D}$$

$$\begin{array}{c}\text{Section ratio}\\ \text{(for box sections)}\end{array} = \frac{\text{breadth of section across wind front}}{\text{depth of section parallel to wind flow}} = \frac{b}{d}$$

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**Figure 9.2.1 Aerodynamic slenderness and section ratio**

## 2.3 Shielding and solidity factors

2.3.1 Where a structure consists of a framework of members such that shielding takes place, the wind force on the windward frame or member and on the sheltered parts of those behind it is calculated using the appropriate force coefficient. The force coefficient on the sheltered parts is to be multiplied by a shielding factor $\eta$. The values of $\eta$ vary with the solidity and spacing ratio of the framework. Values of $\eta$ are given in *Table 9.2.2 Shielding factor(n)* for the solidity and spacing ratio as defined in *Figure 9.2.2 Solidity ratio and spacing ratio*.

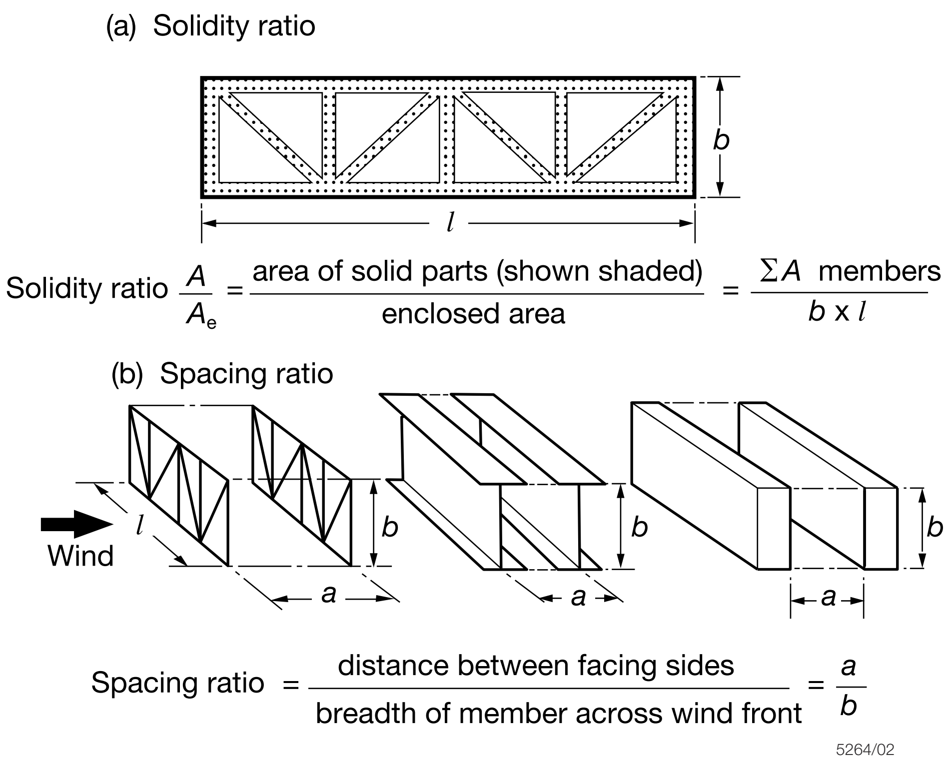


**Figure 9.2.2 Solidity ratio and spacing ratio**

**Table 9.2.2 Shielding factor(n)**

| Spacing ratio | Solidity ratio $A/A_e$ | | | | | |
|---|---|---|---|---|---|---|
| *a/b* | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 |
| 0,5 | 0,75 | 0,4 | 0,32 | 0,21 | 0,15 | 0,1 |
| 1,0 | 0,92 | 0,75 | 0,59 | 0,43 | 0,25 | 0,1 |
| 2,0 | 0,95 | 0,8 | 0,63 | 0,5 | 0,33 | 0,2 |
| 4,0 | 1 | 0,88 | 0,75 | 0,66 | 0,55 | 0,45 |
| 5,0 | 1 | 0,95 | 0,88 | 0,81 | 0,75 | 0,68 |
| 6,0 | 1 | 1 | 1 | 1 | 1 | 1 |

2.3.2 Where a structure consists of a number of identical frames or members spaced equidistantly behind each other in such a way that each frame shields those behind it, the wind load is to be obtained from the following expression:

$$F = APC_f\left(\frac{1-\eta^n}{1-\eta}\right)$$

where

$\eta$ = shielding factor from *Table 9.2.2 Shielding factor(n)* but to be taken as not less than 0,1

$n$ = number of frames, but to be taken as not greater than nine

$C_f$ = force coefficient from *Table 9.2.1 Force coefficient (Cf)*

and *A* and *P* are as defined in *Pt 3, Ch 3, 3.6 Wind loading 3.6.3*.

### 2.4 Tower sections

2.4.1 For latticed tower structures, the `face on' wind force based on the solid area of the windward face is to be calculated using the following factored pressures:

(a) For towers composed of flat-sided sections:

$1,7P(1+\eta)$

(b) For towers composed of circular sections:

where

$DV_s < 6,0\mathrm{m}^2/\mathrm{s}: 1,2P(1+\eta)$

and

$DV_s \geq 6,0\mathrm{m}^2/\mathrm{s}: 1,4P(1+\eta)$

where

= $D$ and $V_s$ are defined in *Table 9.2.1 Force coefficient (Cf)*.

The value of η is taken from *Table 9.2.2 Shielding factor(n)* for *a/b* = 1,0 according to the solidity ratio of the windward face.

2.4.2 The maximum wind load on a square section tower occurs when the wind blows on to a corner and is to be taken as 1,2 times the `face on' load.

## ■ *Section 3* Drag coefficients for pontoons

### 3.1 General

3.1.1 The nature of the forces on floating bodies is considerably complex and not fully understood. In theory, the forces depend on factors such as speed of flow, area normal to the flow, total wetted area, roughness, detailed form or shape, and the proximity of the seabed or other boundaries and bodies. In practice, simplifications are made when describing forces.

### 3.2 Wall-sided boxes

3.2.1 Towing tests on wall-sided boxes have also been performed and results are reproduced in *Table 9.3.1 Typical current drag coefficients for wall-sided boxes*.

**Table 9.3.1 Typical current drag coefficients for wall-sided boxes**

| Shape of model | Breadth/draught ration *B/D* | Drag force coefficient $C_D$ |
|---|---|---|
| Square | 8,1 | 0,72 |
| | 3,4 | 0,70 |
| | 1,6 | 0,86 |
| **Note** A drag coefficient of 1,0 should be used unless reliable values can be obtain. | | |

### 3.3 Pontoons and barges

3.3.1 There are very little data on forces or coefficients for floating structures such as barges and pontoons. However, towing tests on barges have been performed, and graphs of typical drag coefficients are reproduced in *Figure 9.3.1 Longitudinal drag coefficient for rectangular pontoon in deep water*, *Figure 9.3.2 Transverse drag coefficient for rectangular pontoon in deep water*,

*Figure 9.3.3 Longitudinal drag coefficient at various water depths for rectangular pontoon with current head on*, *Figure 9.3.4 Transverse drag coefficient at various water depths for rectangular pontoon with current beam on*.

3.3.2 The coefficients in *Figure 9.3.1 Longitudinal drag coefficient for rectangular pontoon in deep water* and *Figure 9.3.2 Transverse drag coefficient for rectangular pontoon in deep water* and *Table 9.3.1 Typical current drag coefficients for wall-sided boxes* apply when the water is deep (depth/draught ≥ 5). The coefficients in *Figure 9.3.3 Longitudinal drag coefficient at various water depths for rectangular pontoon with current head on* and *Figure 9.3.4 Transverse drag coefficient at various water depths for rectangular pontoon with current beam on* apply in shallow water.

The following equations should be used when applying the coefficients given in *Figure 9.3.1 Longitudinal drag coefficient for rectangular pontoon in deep water*, *Figure 9.3.2 Transverse drag coefficient for rectangular pontoon in deep water*, *Figure 9.3.3 Longitudinal drag coefficient at various water depths for rectangular pontoon with current head on*, *Figure 9.3.4 Transverse drag coefficient at various water depths for rectangular pontoon with current beam on*.

$$F_x = ½ (C_x \rho V^2 A_x)$$

$$F_y = ½ (C_y \rho V^2 A_y)$$

where

$F_x$ = the current force along the longitudinal (x) axis (in kN)

$F_y$ = the current force along the transverse (y) axis (in kN)

$C_x$ = the longitudinal current force drag coefficient

$C_y$ = the transverse current force drag coefficient

$\rho$ = the mass density of water (in t/m$^3$)

$A_x$ = the effective current area normal to the longitudinal (x) axis (in m)

$A_y$ = the effective current area normal to the transverse (y) axis (in m)

$V$ = the incident current velocity (in m/s).

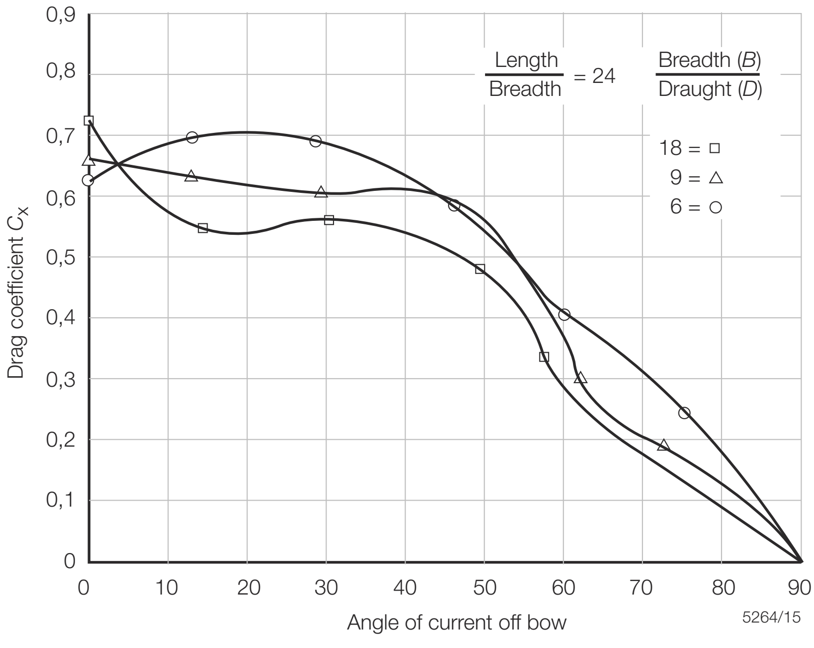


**Figure 9.3.1 Longitudinal drag coefficient for rectangular pontoon in deep water**

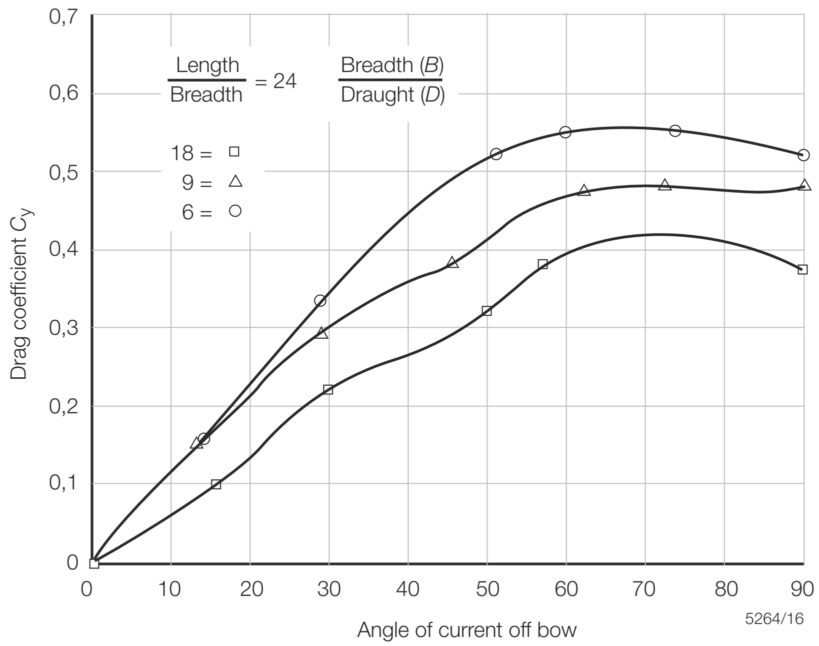


**Figure 9.3.2 Transverse drag coefficient for rectangular pontoon in deep water**

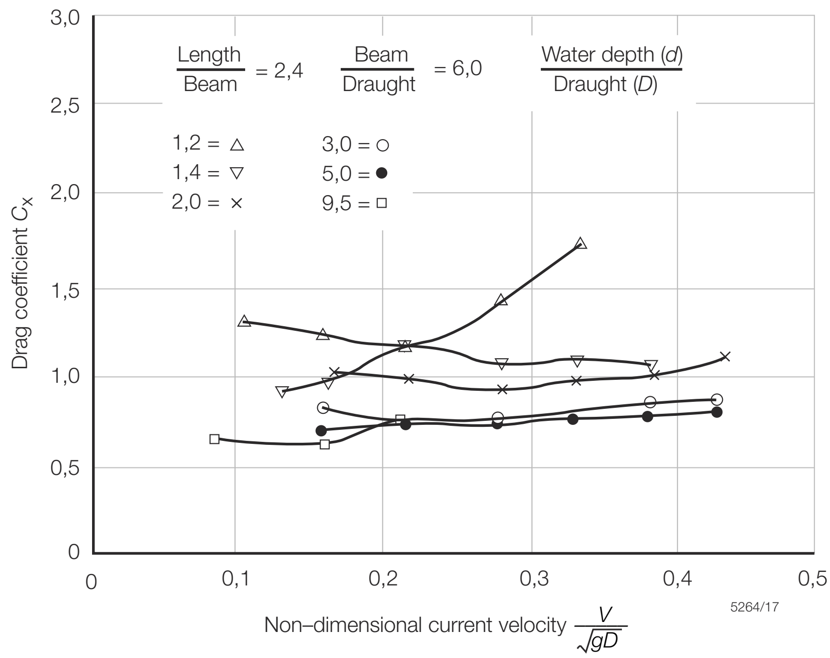


**Figure 9.3.3 Longitudinal drag coefficient at various water depths for rectangular pontoon with current head on**

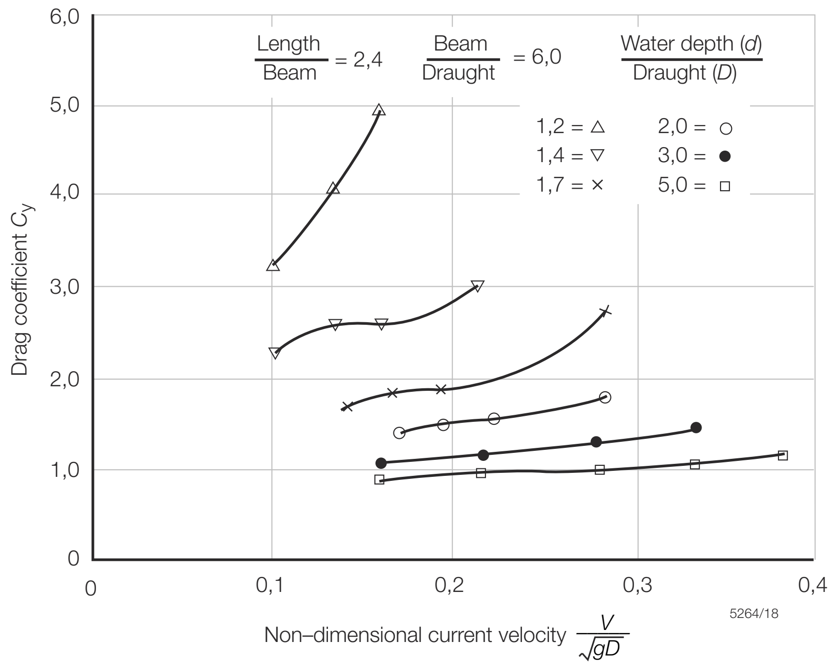


**Figure 9.3.4 Transverse drag coefficient at various water depths for rectangular pontoon with current beam on**

## ■ *Section 1* General

### 1.1 Application

1.1.1 This Chapter is applicable to all linkspans that are either totally or partially supported by buoyant means.

1.1.2 Where it is intended to transport a linkspan pontoon by means of towing or where the pontoon will be lifted into place, the strength of shipboard fittings and supporting hull structures are to be assessed in accordance with the requirements of this Chapter.

1.1.3 The arrangements, equipment and fittings of sufficient safe working load (SWL) are to be provided to enable the safe conduct of all towing and lifting operations.

1.1.4 Shipboard fittings means bollards and bitts, fairleads, stand rollers, chocks used for the towing of the ship, and padeyes, lifting lugs etc. used for the lifting of the ship. Any weld or bolt or equivalent device connecting the shipboard fitting to the supporting structure is part of the shipboard fitting. Other components such as capstans, winches, etc. are not covered by this Chapter.

1.1.5 Supporting hull structures means that part of the ship structure on/in which the shipboard fitting is placed and which is directly submitted to the forces exerted on the shipboard fitting. The supporting hull structure of capstans, winches, etc. used for towing operations mentioned above is also to comply with the requirements specified in this Chapter.

## ■ *Section 2* Towing

### 2.1 Application

2.1.1 The strength of shipboard fittings used for normal towing operations at bow, sides and stern and their supporting hull structures are to comply with the requirements specified in this sub-Section.

### 2.2 Arrangements

2.2.1 Shipboard fittings for towing are to be located on stiffeners and/or girders which are part of the deck construction so as to facilitate efficient distribution of the towing load. Other arrangements are acceptable, provided that the strength is confirmed adequate for the intended service.

### 2.3 Design load

2.3.1 The design load applied to shipboard fittings and supporting hull structure is not to be less than 1,25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the towing arrangements plan.

2.3.2 When a safe towing load (TOW) greater than that determined according to *Pt 3, Ch 10, 2.8 Safe towing load (TOW) 2.8.1* is requested, then the design load is to be increased in accordance with the appropriate TOW/design load relationship given in this Section.

2.3.3 The side projected area is to be considered for selection of towing lines and the loads applied to shipboard fittings and supporting hull structure.

2.3.4 The increase of the minimum breaking strength for synthetic ropes need not to be considered for the loads applied to shipboard fittings and supporting hull structure.

2.3.5 The design load is to be applied to fittings in all directions that could occur by considering the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting, the total design load applied to the fitting is equal to the resultant of the design loads acting on the line, *see Figure 10.2.1 Design load applied to fittings*. However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

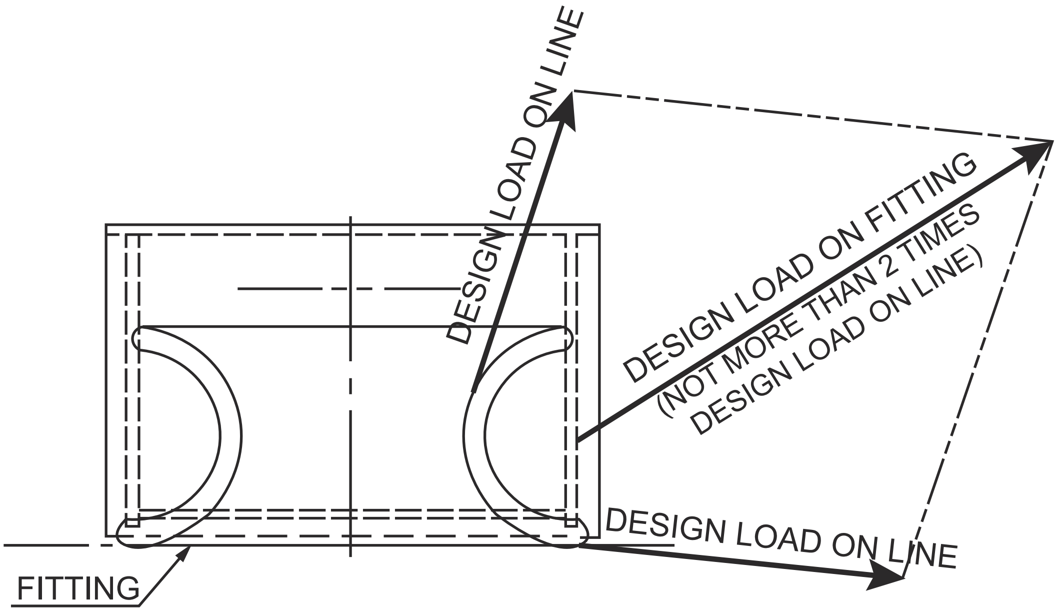


**Figure 10.2.1 Design load applied to fittings**

## 2.4 Strength of fittings

2.4.1 Shipboard fittings are to be selected from an acceptable National or International Standard and to be based on the intended maximum towing load (e.g. static bollard pull) as indicated on the towing arrangements plan.

2.4.2 Towing bitts (double bollards) are to be chosen for the towing line attached with an eye splice if the industry standard distinguishes between different methods to attach the line, i.e. figure-of-eight or eye splice attachment.

2.4.3 When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting based on net scantlings and its attachment to the ship is to be adequate for the loads specified in *Pt 3, Ch 10, 2.3 Design load 2.3.1* based on the acceptance criteria given in *Pt 3, Ch 10, 2.5 Strength of supporting hull structures 2.5.2* or *Pt 3, Ch 10, 2.5 Strength of supporting hull structures 2.5.3* as appropriate. Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with an eye splice. For strength assessment, beam theory or finite element analysis using net scantlings is to be applied, as appropriate. Corrosion additions and wear down allowance is to be added to the net scantlings as defined in *Pt 3, Ch 10, 2.6 Corrosion addition* and *Pt 3, Ch 10, 2.7 Wear allowance*.

## 2.5 Strength of supporting hull structures

2.5.1 The net scantlings of the supporting hull structure for the fittings are to be adequate for the loads specified by the *Pt 3, Ch 10, 2.3 Design load 2.3.1* based on the acceptance criteria given in by *Pt 3, Ch 10, 2.5 Strength of supporting hull structures 2.5.2* or *Pt 3, Ch 10, 2.5 Strength of supporting hull structures 2.5.3* as appropriate. The reinforced members beneath shipboard fittings are to be effectively arranged for any variation of direction (horizontally and vertically) of the towing forces acting upon the shipboard fittings, *see Figure 10.2.2 Supporting hull structure* for a sample arrangement. Proper alignment of the fitting and its supporting hull structure is to be ensured. The acting point of the towing force on a shipboard fitting is to be taken at the attachment point of a towing line or at a change in its direction. For bollards and bitts the attachment point of the towing line is to

be taken not less than 4/5 of the tube height above the base as indicated in *Figure 10.2.2 Supporting hull structure* Corrosion additions and wear down allowance are to be added to the net scantlings as defined in *Pt 3, Ch 10, 2.6 Corrosion addition* and *Pt 3, Ch 10, 2.7 Wear allowance*.

2.5.2 In the case of strength assessment using beam theory or grillage analysis, the stress within the supporting structure of fittings is not to exceed that given in *Table 10.2.1 Allowable stress within the supporting structure of shipboard fittings*.

2.5.3 For strength calculations by means of finite element analysis, the geometry is to be idealised as realistically as possible. The ratio of element length to width is not to exceed 3. Girders are to be modelled using shell or plane stress elements. Symmetric girder flanges are generally to be modelled by beam or truss elements. At least three elements are to be used across the depth of the girder. In way of small openings in girder webs the web thickness is to be reduced to a mean thickness over the web height. Large openings are to be modelled. Stiffeners are generally to be modelled by using shell, plane stress, or beam elements. Stresses are to be read from the centre of the individual element. For shell elements the stresses are to be evaluated at the mid-plane of the element. The equivalent stress within the supporting structure of fittings is not to exceed the specified minimum yield strength of the material.

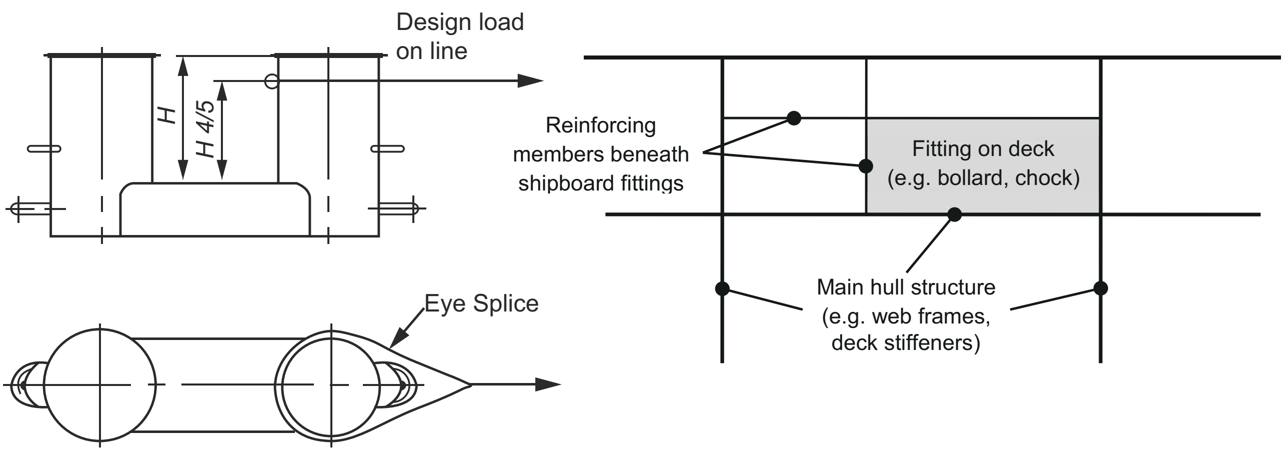


**Figure 10.2.2 Supporting hull structure**

**Table 10.2.1 Allowable stress within the supporting structure of shipboard fittings**

| | Normal stress, in N/mm$^2$ | Shear stress, in N/mm$^2$ |
|---|---|---|
| Allowable stress | $\frac{235}{k}$ | $\frac{141}{k}$ |

where

$k = \frac{235}{\sigma_o}$

$\sigma_o$ = specified minimum yield strength of the material in N/mm$^2$

Note Normal stress is defined as the sum of bending and axial stresses. No stress concentration factors are accounted for and as such may need to be considered separately.

### 2.6 Corrosion addition

2.6.1 An allowance for corrosion is to be added to the net thickness derived as indicated below:

- For the supporting hull structure, a corrosion addition of 2 mm is to be added to the net thickness derived.
- For pedestals and foundations on deck which are not part of a fitting according to an accepted industry standard, 2,0 mm.
- For shipboard fittings not selected from an accepted industry standard, 2,0 mm.

### 2.7 Wear allowance

2.7.1 In addition to the corrosion addition given in *Pt 3, Ch 10, 2.6 Corrosion addition*, the wear allowance, $t_w$, for shipboard fittings that are not selected from an acceptable National or International standard, is not to be less than 1,0 mm, added to surfaces which are intended to regularly contact the line.

### 2.8 Safe towing load (TOW)

2.8.1 The safe towing load (TOW) is the load limit for towing purposes. The TOW used is not to exceed 80 per cent of the design load specified by *Pt 3, Ch 10, 2.3 Design load 2.3.1*.

2.8.2 The TOW, in tonnes, of each shipboard fitting is to be marked (by weld bead or equivalent) on the deck fittings used for towing.

2.8.3 The above requirements on the TOW apply for the use with no more than one towline line. If not otherwise chosen, for towing bitts (double bollards) the TOW is the load limit for a towing line attached with an eye-splice.

2.8.4 The towing and lifting arrangements plan mentioned in *Pt 3, Ch 10, 4.1 Towing and lifting arrangements plan* is to define the method of use of towing lines.

## ■ *Section 3* Lifting

### 3.1 Application

3.1.1 The strength of shipboard fittings used to lift a linkspan pontoon in and out of water and their supporting hull structures are to comply with the requirements of this Section.

### 3.2 Arrangements

3.2.1 Padeyes and lifting lugs are to be located on stiffeners and/or girders which are part of the deck construction so as to facilitate efficient distribution of the lifting load. Other arrangements are acceptable, provided that the strength is confirmed adequate for the intended service.

### 3.3 Padeyes

3.3.1 The provision of padeyes is to be such that a uniform lift is achieved with no off-centre loading of the lifting appliance occurring.

3.3.2 The design of padeyes is to be in accordance with a recognised National or International Standard.

3.3.3 The padeye can be manufactured from one single plate, have a cheek plate fillet welded on each side of the plate or have a boss which is fillet welded through the plate, *see Figure 10.3.1 Acceptable padeye design*. Padeyes where the boss is only partly welded to the plate are not permitted.

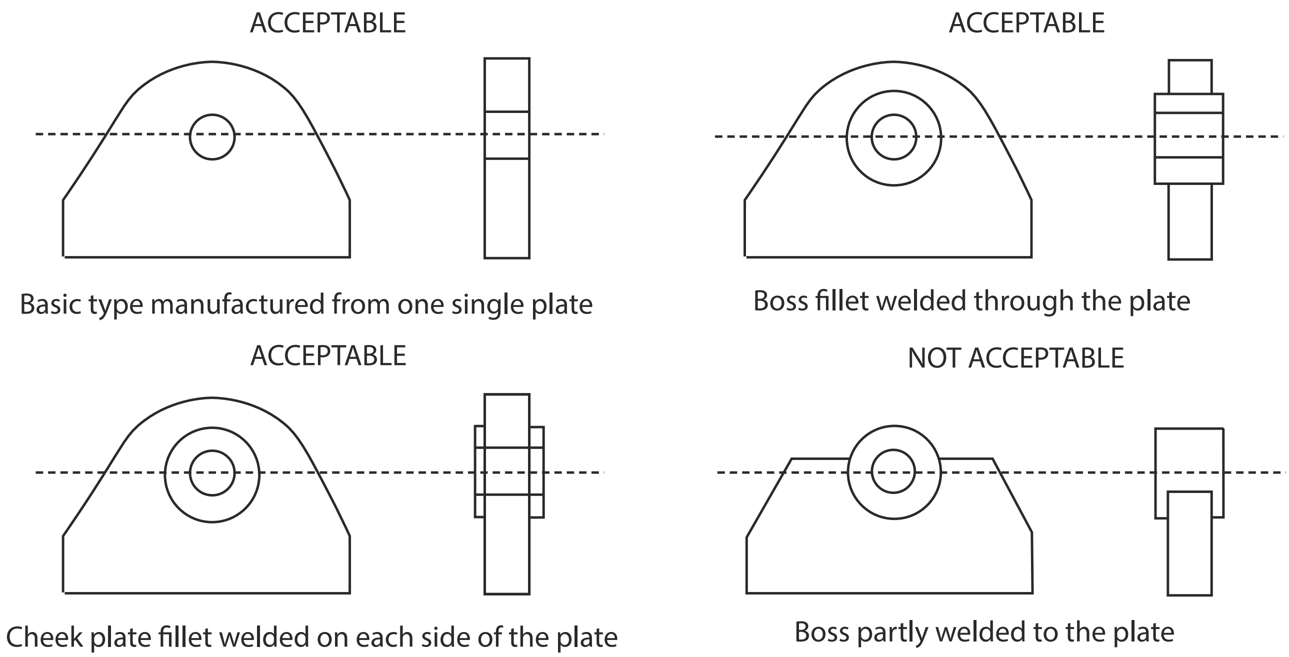


**Figure 10.3.1 Acceptable padeye design**

3.3.4 All padeyes and lifting lugs are to be marked with their specific SWL. The locations and SWL of the padeyes and lifting lugs are to be recorded on the towing and lifting arrangement plan.

3.3.5 All padeyes and lifting lugs are to be tested to 1,5 times the SWL, as a vertical load only.

### 3.4 Strength of supporting hull structures

3.4.1 The net scantlings of supporting hull structures are to be assessed in accordance with *Pt 3, Ch 10, 2.5 Strength of supporting hull structures* where the design load is to be taken as the SWL of the padeye and the acceptance criteria are given in *Table 10.3.1 Allowable stress within the supporting structure of padeyes*. The reinforced members beneath the padeye are to be effectively arranged for any variation of direction (horizontally and vertically) of the lifting forces acting upon the padeye. Corrosion additions and wear down allowance are to be added to the net scantlings as defined in *Pt 3, Ch 10, 2.6 Corrosion addition*.

**Table 10.3.1 Allowable stress within the supporting structure of padeyes**

| | Normal stress, in N/mm$^2$ | Shear stress, in N/mm$^2$ |
|---|---|---|
| Allowable stress | $\frac{157}{k}$ | $\frac{94}{k}$ |

where

$k = \frac{235}{\sigma_o}$

$\sigma_o$ = specified minimum yield strength of the material in N/mm$^2$

Note Normal stress is defined as the sum of bending and axial stresses. No stress concentration factors are accounted for and as such may need to be considered separately.

### 3.5 Global strength

3.5.1 The global strength of the pontoon (longitudinal and transverse) during lifting operations is to be assessed taking into account the hoisting speed of the lifting appliance, the stiffness of the wires, the residual weights, liquids, etc. on the pontoon and the distribution of the padeyes.

## Section 4
## Towing and lifting arrangements plan

### 4.1 Towing and lifting arrangements plan

4.1.1 The SWL and TOW for the intended use for each shipboard fitting are to be noted in the towing and lifting arrangements plan which is to be made available for towing and lifting operations. It is to be noted that the TOW is the load limit for towing purpose and the SWL that for lifting purpose.

4.1.2 Information provided on the plan is to include in respect for each shipboard fitting:

(a) location on the pontoon;
(b) fitting type;
(c) SWL/TOW;
(d) manner of applying towing line load, including limiting fleet angles;
(e) manner of applying lifting load, including limiting angles.

Note Item (c) is subject to approval. Fleet angle is defined as the maximum angle the line deviates from a direction perpendicular to the drum axis of a towing winch. The limiting angles for the purposes of lifting are defined as the maximum angles assumed in the derivation of the SWL for each padeye.

4.1.3 The above information as given *Pt 3, Ch 10, 4.1 Towing and lifting arrangements plan 4.1.2* for towing operations is to be incorporated into the pilot card in order to provide the pilot with proper information on towing operations.

# Contents

Section



## ■ Section 1 General

### 1.1 Systems and components to be constructed under survey

1.1.1 For linkspans built under Special Survey machinery items are to be surveyed at the manufacturer's works. The workmanship is to be to the LR Surveyor's satisfaction. These items are those essential to the operation or safety of the linkspan and include any bilge and ballast pumps, air compressors, air receivers and other pressure vessels covered by *Pt 4, Ch 4, 2.1 Design 2.1.1*, hydraulic pumps and winches.

### 1.2 Alternative system to survey under construction

1.2.1 Alternative methods of survey at the manufacturer's works will be considered.

### 1.3 Systems to be installed and tested under survey

1.3.1 All items and associated systems required for the operation or safety of the linkspan are to be installed and tested under survey, including where applicable, ballast and bilge pumps and systems, air compressors and receivers or other pressure vessels, hydraulic pumps and winches.

### 1.4 Materials

1.4.1 The materials used in the construction are to be manufactured and tested in accordance with the requirements of *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

## ■ Section 2 Information to be submitted

### 2.1 General

2.1.1 Before work is commenced, plans in triplicate of the information listed in *Pt 4, Ch 1, 2.2 Control and safety systems*, *Pt 4, Ch 1, 2.3 Electrical systems*, *Pt 4, Ch 1, 2.4 Piping systems*, *Pt 4, Ch 1, 2.5 Pressure vessels* are to be submitted to LR for approval.

### 2.2 Control and safety systems

2.2.1 Details of the following control systems and safeguards:

(a) Description of operation with explanatory diagrams as appropriate.
(b) Schematic diagrams of control circuits.
(c) Environmental specification of items of control and safety equipment.
(d) Test schedules, including methods of test and required test results.

2.2.2 Items of equipment under control including:

(a) Air compressors used in ballasting.
(b) Bilge and ballast pumps.
(c) Hydraulic pumps and motors for positioning.

(d) Electrical motors for positioning.
(e) Auxiliary engines and ancillary systems.
(f) Winches.
(g) Hydraulic actuators.
(h) Remotely or automatically controlled doors, gates or lifting equipment.
(i) Other automatic or remote means of positioning.

### 2.3 Electrical systems

2.3.1 Single line diagram of power and lighting systems which is to include:

(a) ratings of machines, transformers, batteries and semi-conductor converters,
(b) all feeders connected to the switchboards,
(c) section boards and distribution boards,
(d) insulation type, size and current loadings of cables,
(e) make, type and rating of circuit breakers and fuses.

2.3.2 Simplified diagrams of generator circuits, if fitted, interconnector circuits and feeder circuits showing:

(a) protective devices, e.g. short circuit, overload, reverse power protection,
(b) instrumentation and synchronizing devices,
(c) preference tripping,
(d) remote stops,
(e) earth fault indication/protection.

2.3.3 Calculations of short circuit currents at switchboards and section boards including those fed from transformers, details of circuit breaker and fuse operating times and discrimination curves.

2.3.4 Schedule of normal and emergency loads on the system estimated for the different conditions expected.

### 2.4 Piping systems

2.4.1 Venting, sounding and drainage arrangements for all spaces.

2.4.2 The following diagrammatic plans including details of the material and pipe dimensions/thickness:

(a) Bilge and ballast system including the capacities of the pumps on bilge service.
(b) Hydraulic oil and other flammable liquid systems.
(c) Compressed air systems.
(d) Any other system installed which is necessary for the operation of the facility.

2.4.3 Where it is intended to use plastic pipes for Class I, Class II and any Class III systems for which there are requirements in these Rules, details of the following:

(a) Properties of the materials.
(b) Operating conditions.
(c) Intended service and location.
(d) Pipes, fittings and joints.

2.4.4 Design details of the following components:

(a) Flexible hoses.
(b) Sounding devices.
(c) Resiliently seated valves.
(d) Expansion joints.

### 2.5 Pressure vessels

2.5.1 Plans of pressure vessels where the conditions detailed in *Pt 4, Ch 4, 2.1 Design 2.1.1* apply.

2.5.2 Plans of full constructional features of the vessel and dimensional details of the weld preparations for longitudinal and circumferential seams and attachments, together with particulars of the welding consumables and of the mechanical properties of the materials, are to be submitted before construction is commenced.

## Section 1
## General

### 1.1 General requirements

1.1.1 The electrical installation is to be designed, installed and tested in accordance with IEC Publication 364 *Electrical Installations of Buildings* or other acceptable and relevant National Regulations or Standards for electrical installations.

1.1.2 A `Completion and Inspection' certificate for the electrical installation verifying that the requirements of the relevant regulations have been met is to be provided to LR by an accredited body before the installation is put in service.

### 1.2 Location and construction of equipment

1.2.1 Electrical equipment is, as far as is practicable, to be accessibly placed, clear of flammable material, in well ventilated and adequately lit spaces where flammable gases cannot accumulate and where it is not exposed to risk of mechanical injury or damage from water, oil, etc. Where necessarily exposed to such risks, the equipment is to be suitably constructed or enclosed. Live parts are to be guarded where necessary.

### 1.3 Sources of electrical power

1.3.1 The source of electrical power provided is to have sufficient capacity to supply all electrical services necessary to maintain the facility in the normal operating condition and to have sufficient reserve capacity to permit the starting of the largest motor without causing any motor to stall or any device to fail due to excessive voltage drop on the system.

### 1.4 Fire safety stops

1.4.1 Means are to be provided, at a location outside the space concerned, for stopping machinery space ventilation fans and oil pumps in the event of a fire.

### 1.5 Cable installation

1.5.1 Electric cables for fixed wiring are to be designed, manufactured and tested in accordance with a relevant IEC Publication or an acceptable and relevant National Standard.

1.5.2 Electric cables exposed to risk of mechanical damage are to be protected by suitable protective casings unless the protective covering (e.g. armour or sheath) is sufficient to withstand the possible cause of damage.

1.5.3 Where electric cables are installed in damp or wet locations or may be exposed to oil or harmful vapours e.g. in machinery spaces, they are to have the conductor insulating materials enclosed in an impervious sheath of material appropriate to the expected ambient conditions.

1.5.4 Electric cables are to be effectively supported and secured, without being damaged, by means of flame retardant clips, saddles or straps.

## *Section 1*
## General

### 1.1 General requirements

1.1.1 The requirements of this Chapter apply to the design and construction of safety and control engineering systems.

1.1.2 Compliance with acceptable National Standards which are applicable to the design and construction of safety and control engineering systems on linkspan installations will be considered for classification purposes.

### 1.2 Design

1.2.1 Systems are to be designed to facilitate safe and effective control under normal operational conditions and are to provide appropriate safeguards in the event of system faults or abnormal operating conditions.

### 1.3 Installation and testing

1.3.1 Control systems and safeguards are to be installed and tested under LR survey.

## *Section 2*
## Engineering systems, control and safeguards

### 2.1 Control of equipment

2.1.1 Control systems are to be such that all equipment under control will operate correctly within intended working ranges and will not be subject to detrimental overload or other unintended modes of operation.

2.1.2 Control systems are to be designed to fail-safe, evaluated on the safety requirements of the complete installation.

2.1.3 Control stations are to be located and arranged such that equipment may be effectively controlled by the operator. All information required by the operator for effective control is to be provided at the control station, including indication of status of equipment under control and the presence of unrectified faults.

2.1.4 Where remote or automatic controls are employed, alternative means of operation are to be provided. This may be achieved by local manual control arrangements, subject to all necessary information being available locally.

2.1.5 Failure of any remote or automatic control system is to be indicated at the control station. Further remote or automatic operation is to be prevented until the fault has been cleared and the system manually reset.

2.1.6 Where it is intended that equipment be controlled from more than one location, appropriate interlocks are to be provided to ensure that control is possible from only one control station at any time.

2.1.7 Where a sequence of operations is to be followed automatically, means are to be provided to ensure that all necessary conditions are fulfilled before commencing each stage of the sequence.

### 2.2 Safeguards

2.2.1 Where failure, malfunction or improper operation of the control system may result in an unsafe situation, independent safeguards are to be provided to prevent damage to the equipment under control or injury to persons.

2.2.2 Safeguards are to be independent of the control system and designed to be fail-safe, evaluated on the safety requirements of the complete installation.

2.2.3 Where means are provided to override safeguards, arrangements are to be provided to prevent inadvertent operation of the override. Visual indication is to be provided at the control station at all times when the override is in operation.

2.2.4 Where safeguards rely on a power supply for operation, indication of power supply status is to be provided at the control station.

## ■ *Section 1* General

### 1.1 General requirements

1.1.1 The requirements of this Chapter apply to the design of pressure vessels and the design and construction of piping systems including pipe fittings forming part of such systems.

## ■ *Section 2* Pressure vessels

### 2.1 Design

2.1.1 All pressure vessels where the conditions either (a) or (b) detailed below apply are to be designed in accordance with a pressure vessel standard acceptable to LR:

(a) The vessels contain vapours or gases, e.g. air receivers, hydrophore or similar vessels and $CO_2$ vessels for fire-fighting, and

$pV > 60$
$p > 0,1$
$V > 100$

(b) The vessel contains liquefied gases, for fire-fighting or flammable liquids, and

$p > 0,7$
$V > 100$

where

$V$ = volume in litres

$p$ = design pressure in MPa

## Section 3
## Class of pipes

### 3.1 General

3.1.1 Pipework systems are divided into three classes depending on the internal fluid and design temperature and pressure of the system.

3.1.2 Material requirements for the different classes of pipe are detailed in *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

3.1.3 Acceptable jointing methods for the different classes of pipe are given in the appropriate Section of this Chapter. Material certificate requirements are given in *Pt 4, Ch 4, 9 Material certificates*.

3.1.4 The maximum design pressure and temperature for Class II and III systems are given in *Table 4.3.1 Maximum pressure and temperature conditions for Class II and III piping systems*

**Table 4.3.1 Maximum pressure and temperature conditions for Class II and III piping systems**

| Piping system | Class II | | Class III | |
|---|---|---|---|---|
| | *p* | *T* | *p* | *T* |
| | MPa | °C | MPa | °C |
| Flammable liquids (*see* Note) | 1,6 | 150 | 0,7 | 60 |
| Other media | 4,0 | 300 | 1,6 | 200 |
| **Note** Flammable liquids include hydraulic oil. | | | | |

3.1.5 Class I pipes are to be used where either the maximum design pressure or design temperature exceeds that applicable to Class II pipes.

3.1.6 Class III pipes may also be used for open ended piping e.g. overflows, vents, open-ended drains, sounding pipes, etc.

### 3.2 Design pressure

3.2.1 The design pressure, *p*, is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve.

### 3.3 Design temperature

3.3.1 The design temperature, *T*, is to be taken as the maximum temperature of the internal fluid, but in no case is it to be less than 50°C.

## Section 4
## Carbon steels

### 4.1 General

4.1.1 The minimum thickness of steel pressure pipes is to be in accordance with an acceptable pressure piping code or standard except that in no case is it to be less than shown in *Table 4.4.1 Minimum thickness for steel pipes*.

**Table 4.4.1 Minimum thickness for steel pipes**

| External diameter D<br>mm | Minimum pipe thickness<br>mm |
|---|---|
| 10,2 - 12 | 1,6 |
| 13,5 - 19 | 1,8 |
| 20 - 44,5 | 2,0 |
| 48,3 - 53,5 | 2,3 |
| 70 - 82,5 | 2,6 |
| 88,9 - 108 | 2,9 |
| 114,3 - 127 | 3,2 |
| 133 - 139,7 | 3,6 |
| 152,4 - 168,3 | 4,0 |
| 177,8 and over | 4,5 |

Note 1. The thickness of air, overflow and sounding pipes for structural tanks is to be not less than 4,5 mm.

Note 2. The thickness of bilge, ballast and general sea water pipes is to be not less than 4,5 mm.

Note 3. The thickness of bilge, air, overflow and sounding pipes through ballast tanks and ballast lines through ballast tanks is to be not less than 6,3mm

Note 4. For air, bilge, ballast, overflow, sounding, and venting pipes as mentions in notes 1 to 3, where the pipes are efficiently protected against corrosion, the thickness may be reduced by not more than 1 mm.

4.1.2 For pipes passing through tanks, where the thickness has been determined in accordance with *Pt 4, Ch 4, 4.1 General 4.1.1*, an additional corrosion allowance is to be added to take account of external corrosion; the addition will depend on the external medium and the value is to be in accordance with *Table 4.4.2 Values of corrosion allowance for steel pipes*.

**Table 4.4.2 Values of corrosion allowance for steel pipes**

| Piping Service | Corrosion Allowance (mm) |
|---|---|
| Compressed air systems | 1,0 |
| Hydraulic oil systems | 0,3 |
| Fresh water systems | 0,8 |
| Sea water systems in general | 3,0 |

4.1.3 Where the pipes are efficiently protected against corrosion, the corrosion allowance may be reduced by not more than 50 per cent.

4.1.4 Steel stub pipes between the shell plating and the sea valve are to be of short rigid construction, adequately supported and of substantial thickness.

### 4.2 Steel pipe joints

4.2.1 Joints in steel pipelines may be made by:

(a) Screwed on, or welded on, bolted flanges.

(b) Butt welds between pipes or between pipes and valve chests.

(c) Socket welded joints.

(d) Threaded sleeve joints (parallel thread) (*see also Pt 4, Ch 4, 4.5 Threaded sleeve joints (parallel thread)*).

(e) Special types of approved joints that have been shown to be suitable for the design conditions (*see also Pt 4, Ch 4, 4.4 Screwed fittings*).

4.2.2 Where pipes are joined by welding, a suitable number of flanged joints are to be provided at suitable positions to facilitate installation and removal for maintenance.

4.2.3 For welded pipes protected against corrosion, the corrosion protection is to be applied after welding or made good in way of the weld damaged area.

4.2.4 Where it is not possible to make good the corrosion protection of the weld damaged area, the pipe is to be considered to have no corrosion protection.

4.2.5 Where backing rings are used for welding pipes, the effect of the flow obstruction of the backing ring and erosion/crevice corrosion of the backing ring is to be taken into account.

### 4.3 Welded on flanges, butt welded joints and fabricated branch pieces

4.3.1 The dimensions and material of flanges and bolting, and the pressure-temperature rating of bolted flanges in pressure pipelines is to be in accordance with a recognized National or other established Standard.

4.3.2 The types of welded-on flanges are to be suitable for the pressure, temperature and service for which the pipes are intended.

4.3.3 Welded-on flanges are not to be a tight fit on the pipes. The maximum clearance between the bore of the flange and the outside diameter of the pipe is to be 3 mm at any point, and the sum of diametrically opposite clearances is not to exceed 5 mm.

4.3.4 Where butt welds are employed in the attachment of necked flanges in pipe-to-pipe joints or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding or machining, provided that the pipe wall is not reduced below the design thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to the thickness of the thinner at the butt joint. The welding necks of valve chests are to be sufficiently long to ensure that the valves are not distorted as the result of welding and subsequent heat treatment of the joints.

4.3.5 Where backing rings are used with a necked flange they are to fit closely to the bore of the pipe and are to be removed after welding. The rings are to be made of the same material as the pipes or of mild steel having a sulphur content not greater than 0,05 per cent.

4.3.6 Branches may be attached to pressure pipes by means of welding, provided that the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively that the thickness of pipe and branch is increased to maintain the strength of the pipe. These requirements also apply to fabricated branch pieces.

### 4.4 Screwed fittings

4.4.1 Screwed fittings, including compression fittings, may be used in piping systems not exceeding 41 mm outside diameter. Where the fittings are not in accordance with an acceptable standard then LR may require the fittings to be subjected to special tests to demonstrate their suitability.

### 4.5 Threaded sleeve joints (parallel thread)

4.5.1 Threaded sleeve joints in accordance with a recognized National or other established standard may be used in Class III piping systems. They are not to be used in piping systems conveying flammable liquids.

### 4.6 Socket weld joints

4.6.1 Socket weld joints may be used in Class I and Class II piping systems with carbon steel pipes up to 50 mm nominal diameter, and in Class III systems for any pipe diameter. Socket weld fittings are to be of forged steel and the material is to be compatible with the associated piping. Such joints are not to be used where fatigue, severe erosion or crevice corrosion is expected to occur.

4.6.2 The thickness of the socket weld fittings is to meet the requirements of *Pt 4, Ch 4, 4.1 General 4.1.1* but is to be not less than 1,25 times the nominal thickness of the pipe or tube. The diametrical clearance between the outside diameter of the pipe

and the bore of the fitting is not to exceed 0,8 mm, and a gap of approximately 1,5 mm is to be provided between the end of the pipe and the bottom of the socket.

4.6.3 The leg lengths of the fillet weld connecting the pipe to the socket weld fitting are to be such that the throat dimensions of the weld are not less than the nominal thickness of the pipe or tube.

### 4.7 Welded sleeve joints

4.7.1 Welded sleeve joints may be used in Class III systems only, subject to the restrictions and general dimensional requirements stated in *Pt 4, Ch 4, 4.6 Socket weld joints* for socket weld joints.

4.7.2 The pipe ends are to be located in the centre of the sleeve with a 1,5 to 2,0 mm gap.

## ■ *Section 5* Copper and copper alloys

### 5.1 General

5.1.1 Copper and copper alloy pipes are acceptable for a wide range of services, including bilge pipework and where non heat-sensitive material is required.

5.1.2 The maximum permissible service temperature of copper and copper alloy pipes, valves and fittings is not to exceed 200°C for copper and aluminium brass and 300°C for copper-nickel. Cast bronze valves and fittings complying with the requirements of *Ch 9 Copper Alloys* may be accepted up to 260°C.

5.1.3 The minimum thickness of copper and copper alloy pressure pipes is to be in accordance with an acceptable pressure piping code or standard except that in no case is it to be less than that shown in *Table 4.5.1 Minimum thickness for copper and copper alloy pipes*.

**Table 4.5.1 Minimum thickness for copper and copper alloy pipes**

| Standard pipe sizes (outside diameter) | | | Minimum overriding nominal thickness | |
|---|---|---|---|---|
| | | | Copper | Copper alloy |
| mm | | | mm | mm |
| 8 | to | 10 | 1,0 | 0,8 |
| 12 | to | 20 | 1,2 | 1,0 |
| 25 | to | 44,5 | 1,5 | 1,2 |
| 50 | to | 76,1 | 2,0 | 1,5 |
| 88,9 | to | 108 | 2,5 | 2,0 |
| 133 | to | 159 | 3,0 | 2,5 |
| 193,7 | to | 267 | 3,5 | 3,0 |
| 273 | to | 457,2 | 4,0 | 3,5 |
| 508 | and | over | 4,5 | 4,0 |

5.1.4 Pipes are to be seamless, and branches are to be provided by cast or stamped fittings, pipe pressing or other approved fabrications.

5.1.5 Brazing and welding materials are to be suitable for the operating temperature and for the medium being carried.

5.1.6 Where silver brazing is used, strength is to be obtained by means of the bond in a capillary space over the whole area of the mating surfaces. A fillet braze at the back of the flange or at the face is undesirable. The alloy used for silver brazing is to contain not less than 49 per cent silver.

5.1.7 The use of copper-zinc brazing alloy is not permitted.

### 5.2 Heat treatment

5.2.1 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of manufacture and prior to testing by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

## ■ *Section 6*
## Cast iron

### 6.1 General

6.1.1 Grey cast iron valves and fittings will, in general, be accepted in Class III piping systems except as stated in *Pt 4, Ch 4, 6.1 General 6.1.6*.

6.1.2 Consideration will be given to the acceptance of grey cast iron for valve bodies and parts in Class I hydraulic oil piping systems where failure would not render the system inoperative or introduce a fire risk.

6.1.3 Spheroidal or nodular graphite iron castings for valves and fittings in Class II and Class III piping systems are to be made in a grade having a specified minimum elongation not less than 12 per cent of a gauge length of 5,65 $\sqrt{S_o}$ , where $S_o$ is the actual cross-sectional area of the test piece.

6.1.4 Proposals for the use of spheroidal graphite iron in Class I piping systems will be considered, but in no case is the material to be used in systems where the design temperature exceeds 350°C.

6.1.5 Where the elongation is less than the minimum required by *Pt 4, Ch 4, 6.1 General 6.1.3*, the material is, in general, to be subject to the same limitations as grey cast iron.

6.1.6 Grey cast iron is not to be used for the following:

(a) Valves and fittings for piping systems subject to shock or vibration.
(b) Shell valves and fittings.

## ■ *Section 7*
## Austenitic stainless steel

### 7.1 General

7.1.1 The minimum thickness of austenitic stainless steel pipes in Class I and II piping systems is to be in accordance with an acceptable pressure piping standard using a suitable corrosion allowance.

7.1.2 In no case is the thickness of austenitic stainless steel pipes to be less than that shown in *Table 4.7.1 Minimum thickness for austenitic stainless steel pipes*.

7.1.3 Joints in austenitic stainless steel pipework may be made by any of the techniques described in *Pt 4, Ch 4, 4.2 Steel pipe joints*.

7.1.4 Where pipework is butt welded, this should preferably be accomplished without the use of backing rings, in order to eliminate the possibility of crevice corrosion between the backing ring and pipe.

**Table 4.7.1 Minimum thickness for austenitic stainless steel pipes**

| Standard pipe sizes (outside diameter) in mm | Minimum thickness, in mm |
|---|---|
| 8,0 to 10,0 | 0,8 |
| 10,2 to 17,2 | 1,0 |

| | |
|---|---|
| 21,3 to 48,3 | 1,6 |
| 60,3 to 88,9 | 2,0 |
| 114,3 to 168,3 | 2,3 |
| 219,1 | 2,6 |
| 273,0 | 2,9 |
| 323,9 to 406,4 | 3,6 |
| over 406,4 | 4,0 |
| Note Diameters and thicknesses according to national or international standards may be accepted. | |

## Section 8
## Plastic pipes

### 8.1 General

8.1.1 Proposals to use plastic pipes in shipboard piping systems will be considered in relation to the properties of the materials, the operating conditions, the intended service and location. Details are to be submitted for approval. Special consideration will be given to any proposed service for plastic pipes not mentioned in these Rules.

8.1.2 5Plastic pipes and fittings will, in general, be accepted in Class III piping systems. Proposals for the use of plastic in Class I and Class II piping systems will be specially considered.

8.1.3 For Class I, Class II and any Class III piping systems for which there are Rule requirements, the pipes are to be of a type which has been approved by LR.

8.1.4 For domestic and similar services where there are no Rule requirements, the pipes need not be of a type which has been approved by LR. However, the fire safety aspects, as referenced in *Pt 4, Ch 4, 8.4 Fire performance criteria* and *Pt 4, Ch 4, 8.5 Additional fire performance criteria applicable to linkspans*, are to be considered.

8.1.5 The use of plastic pipes may be restricted by statutory requirements of the National Authority of the country in which the vessel is to be registered.

### 8.2 Design and performance criteria

8.2.1 Pipes and fittings are to be of robust construction and are to comply with an acceptable National or International Standard, consistent with the intended use. Particulars of pipes, fittings and joints are to be submitted for consideration.

8.2.2 The design and performance criteria of all piping systems, independent of service or location, are to meet the requirements of *Pt 4, Ch 4, 8.3 Design strength*.

8.2.3 Depending on the service and location, the fire safety aspects, such as fire endurance, flame spread, smoke generation, toxicity and fire protection coatings, are to meet the requirements of *Pt 4, Ch 4, 8.4 Fire performance criteria* and *Pt 4, Ch 4, 8.5 Additional fire performance criteria applicable to linkspans*.

8.2.4 Plastic piping, connections and fittings are to be electrically conductive when:

(a) carrying fluids capable of generating electrostatic charges; or
(b) passing through hazardous zones and spaces, regardless of the fluid being conveyed.

Suitable precautions against the build-up of electrostatic charges are to be provided in accordance with the requirements of *Pt 4, Ch 4, 8.6 Electrical conductivity*.

### 8.3 Design strength

8.3.1 The strength of pipes is to be determined by hydrostatic pressure tests to failure on representative sizes of pipe. The strength of fittings is to be not less than the strength of the pipes.

8.3.2 The nominal internal pressure, $p_{Ni}$, (in MPa) of the pipe is to be determined by the lesser of the following:

$$p_{Ni} \le \frac{p_{st}}{4}$$

$$p_{Ni} \le \frac{p_{lt}}{4}$$

where

$p_{st}$ = short term hydrostatic test failure pressure, in MPa

$p_{lt}$ = long term hydrostatic test failure pressure (100 000 hours), in MPa

Failure pressures obtained over a reduced period and extrapolated in accordance with a recognised National or International Standard will be specially considered.

8.3.3 In service, the pipe is not to be subjected to a pressure greater than $p_{Ni}$.

8.3.4 The nominal external pressure, $p_{Ne}$, (in MPa) of the pipe, defined as the maximum total of internal vacuum and external static pressure head to which the pipe may be subjected, is to be determined by the following:

$$p_{Ne} \le \frac{p_{col}}{3}$$

where

$p_{col}$ = pipe collapse pressure, in MPa

8.3.5 $p_{col}$ is not to be less than 0,3 MPa.

8.3.6 Piping is to meet the requirements of *Pt 4, Ch 4, 8.3 Design strength* over the range of service temperature which will be experienced in service.

8.3.7 High temperature limits and pressure reductions relative to nominal pressures are to be in accordance with a recognised standard, but in each case the maximum working temperature is to be at least 20°C lower than the minimum temperature for deflection under load of the resin or plastic material without reinforcement. The minimum heat distortion temperature is not to be less than 80°C. *See also Ch 14, 4 Plastic pipes and fittings* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

8.3.8 Where it is proposed to use plastic piping in low temperature services, design strength testing is to be made at a temperature 10°C lower than the minimum working temperature.

8.3.9 The selection of plastic materials for piping is to take account of other factors such as impact resistance, ageing, fatigue, erosion resistance, fluid absorption and material compatibility such that the design strength of the piping is not reduced below that required by these Rules.

8.3.10 Design strength values may be verified experimentally or by a combination of testing and calculation methods.

### 8.4 Fire performance criteria

8.4.1 Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance standards required, the coating is to be resistant to products likely to come into contact with the piping and be suitable for the intended application.

8.4.2 The materials used for plastic pipes, except those fitted on open decks and within tanks, cofferdams, void spaces, pipe tunnels and ducts are to have low flame spread characteristics.

8.4.3 The materials used for plastic pipes within accommodation, service and control spaces are not to be capable of producing excessive quantities of smoke and toxic products that may be a hazard to personnel within those spaces.

### 8.5 Additional fire performance criteria applicable to linkspans

8.5.1 Where plastic pipes are used in systems essential for the safe operation of the linkspan or for containing combustible fluids or sea water where leakage or failure could result in fire or in the flooding of watertight compartments, the pipes and fittings are to be of a type which has been fire endurance tested.

### 8.6 Electrical conductivity

8.6.1 Where a piping system is required to be electrically conductive for the control of static electricity, the resistance per unit length of the pipe, bends, elbows, fabricated branch pieces, etc. is not to exceed 0,1 MΩ/m.

8.6.2 Where a piping system is required to be electrically conductive for the control of static electricity, electrical continuity is to be maintained across the joints and fittings and the system is to be earthed. The resistance to earth from any point in the piping system is not to exceed 1 MΩ.

### 8.7 Manufacture and quality control

8.7.1 All materials for plastic pipes and fittings are to be approved by LR, and are in general to be tested in accordance with *Ch 14, 4 Plastic pipes and fittings* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*. For pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test required by *Ch 14, 4.9 Hydraulic test* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020* may be replaced by testing carried out in accordance with the requirements stipulated in a recognised National or International Standard, consistent with the intended use for which the pipe or fittings are manufactured, provided that there is an effective quality system in place complying with the requirements of *Ch 14, 4.4 Quality assurance* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020* and the testing is completed to the satisfaction of the LR Surveyor.

8.7.2 The material manufacturer's test certificate, based on actual tested data, is to be provided for each batch of material.

8.7.3 Plastic pipes and fittings are to be manufactured at a works approved by LR in accordance with agreed quality control procedures which shall be capable of detecting at any stage (e.g. incoming material, production, finished article, etc.) deviations in the material, product or process.

8.7.4 Plastic pipes are to be manufactured and tested in accordance with *Ch 14, 4 Plastic pipes and fittings* of the *Rules for the Manufacture, Testing and Certification of Materials, July 2020*. For Class III piping systems the pipe manufacturer's test certificate may be accepted in lieu of an LR Certificate and is to be provided for each consignment of pipe.

### 8.8 Construction and installation

8.8.1 All pipes are to be adequately but freely supported. Suitable provision is to be made for expansion and contraction to take place without unduly straining the pipes.

8.8.2 Pipes may be joined by mechanical couplings or by bonding methods such as welding, laminating and adhesive bonding.

8.8.3 Where bonding systems are used, the manufacturer or installer shall provide a written procedure covering all aspects of installation, including temperature and humidity conditions. The bonding procedure is to be approved by LR.

8.8.4 The person carrying out the bonding is to be qualified. Records are to be available to the Surveyor for each qualified person showing the bonding procedure and performance qualification, together with dates and results of the qualification testing.

8.8.5 Conditions during installation, such as temperature and humidity, which may affect the strength of the finished joints, are to be in accordance with the agreed bonding procedure.

8.8.6 The required fire endurance level of the pipe is to be maintained in way of pipe supports, joints and fittings, including those between plastic and metallic pipes.

8.8.7 Where piping systems are arranged to pass through watertight bulkheads or decks, provision is to be made for maintaining the integrity of the bulkhead or deck by means of metallic bulkhead or deck pieces. The bulkhead or deck pieces are to be of substantial construction and suitably protected against corrosion and so constructed to be of a strength equivalent to the intact bulkhead; attention is drawn to *Pt 4, Ch 4, 8.8 Construction and installation 8.8.1*, details of the arrangements are to be submitted for approval.

8.8.8 Pipes or other fittings attached directly to the plating of tanks and to bulkheads, which are required to be of watertight construction, are to be secured by means of studs screwed through the plating or by tap bolts, and not by bolts passing through clearance holes. Alternatively, the studs or the bulkhead or tank pieces may be welded to the plating.

### 8.9 Additional requirements for testing plastic pipes for linkspans

8.9.1 Where a piping system is required to be electrically conductive, tests are to be carried out in accordance with *Pt 4, Ch 4, 8.6 Electrical conductivity*

8.9.2 The hydraulic testing of pipes and fittings is to be in accordance with *Pt 4, Ch 4, 12 Hydraulic tests on pipes and fittings*

8.9.3 In the case of pipes intended for essential services each qualified person is, at the place of construction, to make at least one test joint, representative of each type of joint to be used. The joined pipe section is to be tested to an internal hydrostatic pressure of four times the design pressure of the pipe system and the pressure held for not less than one hour, with no leakage or separation of joints. The bonding procedure test is to be witnessed by the Surveyor.

## ■ *Section 9* Material certificates

### 9.1 Metallic materials

9.1.1 Materials for Class I and II piping systems and components, as defined in *Table 4.3.1 Maximum pressure and temperature conditions for Class II and III piping systems*, and also the material for shell valves and fittings are to be manufactured and tested in accordance with *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

9.1.2 Ferrous castings and forgings for Class I and II piping systems are to be produced at a works approved by LR.

9.1.3 Materials for Class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable National Standards.

9.1.4 The manufacturer's materials test certificate will be accepted for all classes of piping and components in lieu of an LR materials certificate where the maximum design conditions are less than shown in *Table 4.9.1 Maximum conditions for pipes, valves and fittings for which Manufacturer's materials test certificate is acceptable*

**Table 4.9.1 Maximum conditions for pipes, valves and fittings for which Manufacturer's materials test certificate is acceptable**

| Material | Working temperature °C | $DN$ = nominal diameter, mm<br>$P_w$ = working presser, MPa |
|---|---|---|
| Carbon and low alloy, steel.<br>Stainless steel.<br>Spheroidal or nodular cast iron. | < 300 | $DN < 50$<br>or<br>$P_w \times DN < 250$ |
| Copper alloy | < 200<br>or<br>$P_w \times DN < 150$ | $DN < 50$ |

### 9.2 Non-metallic materials

9.2.1 Pipes and fittings intended for applications in Class I, Class II and Class III systems for which there are Rule requirements are to be manufactured in accordance with *Rules for the Manufacture, Testing and Certification of Materials, July 2020*.

## ■ *Section 10* Requirements for valves

### 10.1 General

10.1.1 All valves are to be so constructed as to prevent the possibility of valve covers or glands being slackened back or loosened when the valves are operated.

10.1.2 All valves are to be arranged to shut with a right-hand (clockwise) motion of the wheels and are to be provided with indicators showing whether they are open or shut unless this is readily obvious.

10.1.3 Valves and cocks are to be fitted with legible nameplates and, except for submerged valves in ballast systems, are to be fitted in places where they are at all times readily accessible.

10.1.4 Shell valves are to be fitted in accessible positions and are to be capable of being operated from positions which are readily accessible in case of influx of water to the compartment.

10.1.5 Valve hand wheels and cock handles are to be suitably retained on the spindles.

10.1.6 Shell valves are to be hydraulically tested before installation in accordance with *Pt 4, Ch 4, 12 Hydraulic tests on pipes and fittings*.

10.1.7 All valves which are provided with remote control are to be arranged for local manual operation, independent of the remote operating mechanism.

10.1.8 Valves having isolation or sealing components sensitive to heat are not to be used in spaces where leakage or failure caused by fire could result in fire spread, flooding or the loss of an essential service.

## ■ *Section 11*
## Requirements for flexible hoses

### 11.1 General

11.1.1 Short joining lengths of flexible hoses of approved type may be used, where necessary, to accommodate relative movement between various items of machinery connected to permanent piping systems.

11.1.2 Prototype pressure tests are to be carried out on each new type of hose, complete with end fittings, and in no case is the bursting pressure to be less than five times the maximum working pressure in service.

### 11.2 Applications for rubber hoses

11.2.1 Synthetic rubber hoses, with integral cotton or similar braid reinforcement, may be used in fresh and sea water systems, but not for fire extinguishing salt water services.

11.2.2 Synthetic rubber hoses for use in bilge, ballast, compressed air, hydraulic oil and other flammable liquid systems are to have single or double closely woven integral wire braid reinforcement or be otherwise inherently fire resistant and of an approved fire tested type.

## ■ *Section 12*
## Hydraulic tests on pipes and fittings

### 12.1 Hydraulic tests before installation

12.1.1 All Class I and II pipes and their associated fittings are to be tested by hydraulic pressure. Further, compressed air and flammable liquid pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 0,7 MPa. The test is to be carried out after completion of manufacture and before installation and, where applicable, before insulating and coating.

12.1.2 The test pressure is to be 1,5 times the design pressure, as defined in *Pt 4, Ch 4, 3.2 Design pressure*.

12.1.3 Valves, cocks and distance pieces intended for installation on the shell are to be tested by hydraulic pressure to not less than 0,5 MPa.

### 12.2 Testing after assembly

12.2.1 Flammable liquid piping is to be tested by hydraulic pressure, after installation, to 1,5 times the design pressure but in no case to less than 0,35 MPa.

12.2.2 Where pipes specified in *Pt 4, Ch 4, 12.1 Hydraulic tests before installation 12.1.1* are butt welded together during assembly, they are to be tested by hydraulic pressure, in accordance with the requirements of *Pt 4, Ch 4, 12.2 Testing after*

*assembly 12.2.1*, after welding. The pipe lengths may be insulated, except in way of the joints made during installation and before the hydraulic test is carried out.

12.2.3 The hydraulic test required by *Pt 4, Ch 4, 12.2 Testing after assembly 12.2.2* may be omitted provided satisfactory non-destructive tests by ultrasonic or radiographic methods are carried out on the entire circumference of all butt welds.

12.2.4 Where ultrasonic tests have been carried out, the manufacturer is to provide the Surveyor with a signed statement confirming that ultrasonic examination has been carried out by an approved operator and that there were no indications of defects which could be expected to have a detrimental effect on the service performance of the piping.

## ■ *Section 1* General

### 1.1 General requirements

1.1.1 The requirements of this Chapter apply to piping systems on all types of linkspans.

1.1.2 Consideration will be given to special cases or to arrangements which are equivalent to those required by these Rules.

## ■ *Section 2* Construction and installation

### 2.1 Materials

2.1.1 Except where otherwise stated in this Chapter, pipes valves and fittings are to be made of steel, cast iron, copper alloy, or other approved material suitable for the intended service.

2.1.2 Where applicable, the materials are to comply with the relevant requirements of *Pt 4, Ch 4 Piping and Pressure Vessel Design Requirements*.

### 2.2 Installation

2.2.1 All pipes for essential services are to be secured in position to prevent chafing or lateral movement.

2.2.2 Long or heavy lengths of pipe are to be supported by bearers so that no undue load is carried by pipe connections or pumps and fittings to which they are attached.

2.2.3 All pipes situated in positions where they are liable to mechanical damage are to be efficiently protected.

2.2.4 After installation, all hydraulic, compressed air and other piping systems together with associated fittings are to be subjected to a running test at the design operating conditions.

### 2.3 Provision for expansion

2.3.1 Suitable provision for expansion is to be made, where necessary, in each range of pipes.

2.3.2 Where expansion pieces are fitted, arrangements are to be provided to protect against over extension and compression. The adjoining pieces are to be suitably aligned, supported, guided and anchored. Where necessary, expansion pieces of the bellows type are to be protected against mechanical damage.

## Section 3
## Shell fittings

### 3.1 Construction

3.1.1 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the pontoon shell or to fabricated water boxes attached to the shell plating.

3.1.2 Distance pieces of short rigid construction and made of approved material may be fitted between the valve and shell. The thickness of such distance pieces is to be equivalent to the pontoon shell thickness.

3.1.3 The arrangements are to be such that the section of pipe immediately inboard of the shell valve may be removed without affecting the watertight integrity of the structure.

## Section 4
## Bilge pumping and drainage systems

### 4.1 General

4.1.1 Arrangements are to be made for draining all watertight compartments other than those intended for permanent storage of fluids. Where drainage is not considered necessary, drainage arrangements may be omitted provided the safety of the linkspan is not impaired.

4.1.2 Pumping arrangements are to be provided having suctions and means of drainage so arranged that any water within any watertight compartment of the linkspan or any watertight section of any compartment, can be pumped out through at least one suction under all possible conditions of operation.

4.1.3 The bilge pumping system is to be designed to prevent water flowing from one watertight compartment to another.

4.1.4 Small compartments may be drained by individual hand pump suctions.

4.1.5 Where the safety or operation of the linkspan could be affected by the ingress of water into a space provided with bilge pumping arrangements, the space is to be provided with a bilge level alarm.

### 4.2 Bilge drainage of machinery spaces

4.2.1 The bilge drainage arrangements are to comply with *Pt 4, Ch 5, 4.1 General*, except that the arrangements are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions under all possible design operating and survival conditions.

4.2.2 Where a bilge main is fitted, one of the suctions referred to in *Pt 4, Ch 5, 4.2 Bilge drainage of machinery spaces 4.2.1* is to be a branch bilge suction, i.e. a suction connected to the bilge main. The second bilge suction is to be a direct bilge suction.

4.2.3 Where a bilge main is not fitted, the branch bilge suction referred to in *Pt 4, Ch 5, 4.2 Bilge drainage of machinery spaces 4.2.2* may be replaced by a suction from a submersible bilge pump.

4.2.4 Additional bilge suctions may be required for the drainage of wells or other recesses.

### 4.3 Size of bilge suction pipes

4.3.1 The sizes of bilge suction pipes are to be suitable for the dimensions of the spaces requiring bilge drainage arrangements.

4.3.2 Where a bilge main is fitted, the internal diameter is to be not less than 50 mm.

4.3.3 The diameter of branch bilge suctions is to be not less than 25 mm.

### 4.4 Pumps on bilge service and their connections

4.4.1 Not less than one power pump and one manual bilge pump suitable for bilge pumping duties are to be provided. Each pump is to take suction from the bilge main or other bilge system arrangement for draining all spaces as applicable.

4.4.2 The power driven pumps may be used for other services (other than flammable liquid transfer) but they are to be immediately available for bilge duty when required.

4.4.3 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any pumps so connected is unaffected by the other pumps being in operation at the same time.

4.4.4 Each power operated bilge pumping unit is to be capable of giving a speed of water through the bilge suction piping of not less than 2 m/s.

### 4.5 Prevention of communication between compartments

4.5.1 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or machinery spaces or other dry compartments being placed in communication with the sea or with tanks. For this purpose, screw-down non-return valves are to be provided in the following fittings:

(a) Bilge valve distribution chests.
(b) Direct bilge suctions and bilge pump connections to main bilge line.

4.5.2 Bilge suction pipes are to be entirely separate from sea inlets or from pipes which may be used for filling or emptying spaces where water or oil is carried.

## ■ *Section 5*
## Air, overflow and sounding pipes

### 5.1 General

5.1.1 Air pipes are to be fitted to all tanks, cofferdams, and other compartments which are not fitted with alternative ventilation arrangements.

5.1.2 Air pipes are to be fitted at the opposite end of the tank to that which the filling pipes are placed and/or at the highest part of the tank. Where the tank top is of unusual or irregular profile, consideration will be given to the number and position of the air pipes.

5.1.3 Air pipes to tanks containing flammable liquids which are located in or pass through compartments of high fire risk, or are in the open, are to be of steel or other equivalent material.

### 5.2 Termination of air pipes

5.2.1 Air pipes to tanks and cofferdams extending to the shell plating, or tanks which can be run up from the sea are to be led to above the weather deck.

5.2.2 Air pipes from storage tanks containing hydraulic oil may terminate in the machinery space, provided the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

### 5.3 Air pipe closing appliances

5.3.1 Closing appliances fitted to tank air pipes are to be of a type which will allow the free passage of air or liquid to prevent the tanks being subjected to a pressure or vacuum greater than that for which they are designed, and prevent the free entry of water into the tanks.

5.3.2 Air pipe closing devices are to be type tested in accordance with the test requirements of LR's Type Approval Test Specification Number 2. The flow characteristic of the closing device is to be determined using water. *See Pt 4, Ch 5, 5.5 Size of air pipes*.

5.3.3 If closing appliances are not fitted, air pipes are to be fitted with a goose neck at the open end.

### 5.4 Nameplates

5.4.1 Nameplates are to be affixed to the upper ends of all air and sounding pipes.

### 5.5 Size of air pipes

5.5.1 In all cases, whether a tank is filled by on-board pumps or other means, the total cross-sectional area of air pipes is to be not less than 25 per cent greater than the effective area of the respective filling pipe.

5.5.2 Air pipes are to be generally not less than 38 mm bore. In the case of small gravity filled tanks smaller bore pipes may be accepted but in no case is the bore to be less than 25 mm.

### 5.6 Overflow pipes

5.6.1 For all tanks which can be pumped up, overflow pipes are to be fitted where the pressure head corresponding to the height of the air pipe is greater than that for which the tank is designed.

5.6.2 In the case of tanks containing flammable liquids, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes. Suitable means are to be provided to indicate when overflow is occurring.

5.6.3 Overflow pipes are to be self draining under normal conditions of operation.

5.6.4 Where overflow sight glasses are provided, they are to be in a vertical dropping line and designed such that the oil does not impinge on the glass. The glass is to be of heat resisting quality and adequately protected from mechanical damage.

### 5.7 Combined air and overflow systems

5.7.1 Where a combined air or overflow system is fitted, the arrangement is to be such that in the event of any one of the tanks being bilged, the other tanks cannot be flooded from the sea through combined air pipes or the overflow main. For this purpose, it will normally be necessary to lead the overflow pipe to a point above the waterline.

5.7.2 Where a common overflow main is provided, the main is to be sized to allow any two tanks connected to that main to overflow simultaneously.

### 5.8 Sounding arrangements

5.8.1 Provision is to be made for sounding all tanks and the bilges of those compartments which are not at all times readily accessible. The soundings are to be taken as near the suction pipes as practicable.

5.8.2 An approved level gauge or remote reading level device may be accepted in lieu of a sounding pipe.

5.8.3 Sounding pipes are to be not less than 32 mm internal diameter.

### 5.9 Termination of sounding pipes

5.9.1 Except as permitted by *Pt 4, Ch 5, 5.10 Short sounding pipes*, sounding pipes are to be led to positions which are at all times accessible above the weather deck and, in the case of tanks containing flammable liquids, the sounding pipes are to be led to safe positions in the open.

### 5.10 Short sounding pipes

5.10.1 In machinery spaces, where it is not practicable to extend sounding pipes as mentioned in *Pt 4, Ch 5, 5.9 Termination of sounding pipes* short sounding pipes extending to readily accessible positions above the platform may be fitted.

5.10.2 Short sounding pipes to oil tanks are to be fitted with cocks having parallel plugs with permanently attached handles, so loaded that, on being released, they automatically close the cocks.

## ■ *Section 6*
## Water ballast systems

### 6.1 System arrangements

6.1.1 Spaces intended for ballast are to be provided with suitable means for filling and emptying.

6.1.2 Where the ballasting is adjusted using compressed air, means are to be provided to protect the tanks against over-pressure.

6.1.3 The arrangements for discharging water ballast are to be such that any ballast tank may be discharged by the use of alternative drainage arrangements.

6.1.4 Ballast piping arrangements are to be separate and distinct from other piping systems.

## ■ *Section 7* Hydraulic systems

### 7.1 System arrangements

7.1.1 Hydraulic fluids are to be suitable for the intended purpose under all operating service conditions.

7.1.2 Materials used for all parts of hydraulic seals are to be compatible with the working fluid at the appropriate working temperature and pressure.

7.1.3 Over-pressure protection is to be provided on the discharge side of all pumps. Where relief valves are fitted for this purpose they are to be fitted in closed circuit, i.e. arranged to discharge back to the system oil tank.

7.1.4 Provision is to be made for hand operation of the systems in an emergency, unless an acceptable alternative is available.

7.1.5 Where hydraulic securing is applied, the system is to be mechanically lockable in the closed position so that, in the event of hydraulic system failure, the securing arrangement will remain locked.

## ■ *Section 8* Compressed air systems

### 8.1 System arrangements

8.1.1 Where compressed air is utilized for adjusting ballast or for other operational purposes, the requirements of *Pt 4, Ch 5, 8.1 System arrangements 8.1.2*, *Pt 4, Ch 5, 8.1 System arrangements 8.1.3*, *Pt 4, Ch 5, 8.1 System arrangements 8.1.4* are to be complied with.

8.1.2 If compressed air is the only means of adjusting ballast or is utilized for other essential operational purposes, at least two sources of air supply are to be provided.

8.1.3 Stop valves in compressed air supply lines to closed piping systems are to permit slow opening to avoid sudden pressure rises in piping systems.

8.1.4 Pipelines which are situated on the low pressure side of reducing valves, and which are not designed to withstand the full pressure at the source of supply, are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

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